JANUARY, 1919

BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS

WITH WHICH IS CONSOLIDATED THE

AMERICAN INSTITUTE OF METALS

SPECIAL FEATURES

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PUBLISHED MONTHLY

Bulletin of the American Institute of Mining Engineers

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No. 145 JANUARY 1919

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ADVERTISING

BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS

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No. 145 JANUARY 1919

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FRIENDLY POSSIBILITIES OF ENGINEERING SOCIETIES

Engineers and masters of enterprise are waking fast to the realization that there is something more in the relations of employer and employee than mechanical output, which can be measured mathematically, and that the human side of service must receive greater consideration for the future. So much has been said and written on this subject that it has passed into a truism.

Should not the same element, long neglected, be considered as of even greater importance than questions of administration and membership, in the plans of engineering societies? Should mutual service and interest end with mere technical output by members and the rendering of care and management by officers?

The world is recognizing, as never before, obligations for service to fellowmen due from all, high or low, in rank or wealth. Our technical societies, organized for professional protection and advancement, are, insensibly to themselves, almost without conscious intent, widening their field of service to members and dealing heartily with questions broader than technique. Those who are doing such service find unconsciously more and more satisfaction in work so rendered.

The growth of knowledge that comes to subaltern engineers or veterans by converse and contact with their fellows, working along and versed in the same subjects, brings interest and friendship. In this way are built some of the warmest friendships of life, coming as incidental and pleasurable result of meetings undertaken for other purposes. Should not the friendly purpose, the desire for service one to another, and es-

pecially the wish on the part of the established man and organizations to help their young fellows, be felt to demand attention as an issue of its own rather than as a by-product?

The thought that such service should be an essential part of society life and obligation is strong and growing. It has shown itself in criticism from time to time against hard and indifferent attitudes and routine, as well as by protests that have taken form in the founding of new societies having the social and the service feature for their reason.

In our Institute, not only has the friendly spirit been growing but the call for service was recognized long since by the establishment of an Employment Department. With the nation at war, more engineers than ever before were demanded quickly. The task of finding them was assumed by Engineering Service, whose mission was a patriotic attempt to give the Government the right engineer for the right place and, incidentally, to help the right man to find it. This service has now, under a changed name, been placed by the Engineering Council under the Secretaries of the four Founder Societies. As the Engineering Societies' Employment Bureau, it possesses the largest cataloged body of information in existence regarding engineers of the country and will, without doubt, grow into a department of increasing value that will carry on its files the records of the great majority of engineers of the country. To young engineers, members or not, it will offer services, practically free, for placement in positions; for employers, it will carry a body of men from which can be drawn capacity for almost any task.

This is a forward step of great value, which will be welcomed, especially by the younger men of our Societies. There are those who believe it is but the beginning and that the Societies should increase their points of social contact. Elder men who have achieved their place in the world owe cordiality and acquaintance toward the younger engineers; on the other hand, the younger men should not conceal their vanity or awkwardness under the cloak of modesty, but should show themselves at all times ready to meet, greet, and show interest in the elders, who are far more desirous of knowing and welcoming them than they know.

Further, with such increase of friendly meetings will come not only greater value to the members from their Society connection, but there must and will grow a feeling on the part of such members, especially those who are younger, that they have obligations of service, as well as privileges, when they join a National Society. All these organizations suffer from the fact that too few members take the trouble even to vote at an annual election and but a small proportion at any time attend the meetings. If each member living within the country should make it a rigid item of his annual schedule to attend at least one meeting of the National Society to which he belongs, not only would he benefit greatly thereby through coming to know face to face the men who are doing the bigger things in the profession and the Society, but he would find his own powers of influencing other men growing proportionately. The obligation of cordiality is on every one.

PHILIP N. MOORE, *Past President*.

ONE HUNDRED NINETEENTH MEETING OF THE INSTITUTE

Coöperation will be the keynote of the meeting of the Institute that will be held in New York on February 17 to 20. Arrangements are being made for twq joint sessions with the Canadian Mining Institute, on the same day, which therefore will be known as Canadian Mining Institute Day. On the afternoon of Wednesday, February 19, there will be a joint session with the American Institute of Electrical Engineers. Besides, we will receive six or eight papers through the National Research Council, four of which will be presented at the National Research Council Session. In March, at the next meeting, of the Canadian Mining Institute, there will be an American Institute of Mining Engineers Day.

The plan is to have the same subjects discussed at both meetings, but by different speakers. One speaker on each subject will represent the Canadian Mining Institute, and one speaker the American Institute of Mining Engineers. The Canadians and the Americans who will speak in Canada are expected to attend the discussion in New York. In addition the discussion at the New York meeting will be sent to Canada in printed form, so that the Canadian discussion will be a continuation of the former.

At the joint session with the American Institute of Electrical Engineers, there will be presented six very important papers on the subject of Electric Welding, one by the Chairman of the Electric Welding Research Committee of the National Research Council, another by the Chairman of the Metallurgical Sub-committee of that same Committee, and a third by Comfort A. Adams, President of the American Institute of Electrical Engineers and Chairman of the Welding Committee of the Emergency Fleet Corporation.

We will receive six or eight papers through the National Research Council. These papers are results of recent investigations and represent the last word in their respective subjects.

The excursion on Thursday, February 20, will be to Newark Bay to visit the Federal Shipyard where the first electric-welded ship is being built. Philip W. Henry is chairman of the excursion committee of arrangements.

The following program has been planned:

MONDAY, FEBRUARY 17, 1919

9.00 a. m. to 9.00 p. m.	Registration at Institute Headquarters.
10.00 a. m.	Simultaneous Sessions of Institute of Metals Division and Industrial Organization.
12.30 p. m.	Luncheon at Headquarters.
2.00 p. m. to 5.00 p. m.	Simultaneous Sessions of Institute of Metals Division and of Industrial Organization.
3.00 p. m.	Visit to the Morgan Galleries.
8.30 p. m.	Evening Entertainment.

TUESDAY, FEBRUARY 18, 1919

Canadian Mining Institute Day

9.30 a. m.	Annual Business Meeting.
10.00 a. m.	Simultaneous Sessions on Principles of Taxation and on Iron and Steel.

11.00 a. m.	Meeting of the Women's Auxiliary.
12.00 p. m.	Meeting of the Boards of Directors.
12.30 p. m.	Luncheon at Headquarters.
	The Directors will entertain at Luncheon at the Engineers' Club, the distinguished visitors.
2.30 to 5.00 p. m.	Discussion of International Coöperation in Mining in North America.
	Improved Relations of Capital and Labor.
	Uniform Mining Law for North America.
3.00 p. m.	Visit to Metropolitan Museum of Art and Senator Clark's Galleries.
8.30 p. m.	Smoker.

WEDNESDAY, FEBRUARY 19, 1919

10.00 a. m.	National Research Council Session.
10.00 a. m.	Session on Mining, Milling and Geology.
11.00 a. m.	Meeting of Womens' Auxiliary.
12.30 p. m.	Luncheon at Headquarters.
2.30 p. m.	Matinee for the Ladies.
2.30 p. m. to 5.00 p. m.	Joint Session with American Institute of Electrical Engineers on Electric Welding.
6.30 p. m.	President's Reception.
7.30 p. m.	Annual Banquet followed by Dancing.

THURSDAY, FEBRUARY 20, 1919

All-day trip or excursion.

The papers that have already been accepted for the next meeting, and the Bulletin in which they appear, are as follows:

Economic and Geologic Conditions in North Argentine-Bolivian Field of South America, by S. C. Herold, September; Petrographic Notes on Ore Deposits at Jerome, Ariz., by Marion Rice, September; Notes on Certain Ore Deposits of the Southwest, by W. Tovote, October.

Mining Methods at the United Verde Extension Mining Co., by C. A. Mitke, January. A Study of Shoveling as Applied to Mining, by G. T. Harley, February.

Cement Plugging for the Exclusion of Bottom Water in the Augusta Field, Kans., by H. R. Shidel, October; Water Troubles in the Mid-continent Oil Fields, and their Remedies, by D. Hager and G. W. McPherson, October; Natural-gas Storage, by L. S. Panyity, January; Petroleum Hydrology Applied to Mid-continent Fields, by Roy O. Neal, January.

Metallographic Investigation of Transverse-fissure Rails with Specific Reference to High-phosphorus Streaks, by G. F. Comstock, November.

Notes on Development of Grain Boundaries in Heat-treated Alloy Steels, by R. S. Archer, January.

Notes on Certain Defects as Shown in Transverse Tests of Nickel Steel Gun Forgings, by C. Y. Clayton, F. B. Foley and F. B. Laney, February.

Does Forging Increase Specific Density of Steel? by H. E. Doerr, January; Production of Ferromanganese in the Blast Furnace, by P. H. Royster, February; Static, Dynamic, and Notch Toughness, by S. L. Hoyt, February; Shimer Case-hardening Process, by J. W. Richards, February.

Notes on Microstructure of Iron Deposited by Electric Arc Welding,

by G. F. Comstock January; Fusion Welding of Mild Steel, by H. M. Hobart, February.

Volatilization of Cuprous Chloride on Melting Copper Containing Chlorine, by S. Skowronski and K. W. McComas, February.

Comparison of Grain-size Measurements and Brinell Hardness of Cartridge Brass, by W. H. Bassett and C. H. Davis, January.

First Year of Leaching at New Cornelia, by H. A. Tobelmann and J. A. Potter, February; Automatic Copper Plating, by J. W. Richards, January; Effect of Temperature, Deformation and Grain Size on the Mechanical Properties of Metals, by Zay Jeffries, February; Electric Furnace Problems, by J. L. McK. Yardley, October; Die Castings and Their Application to Our War Program, by Charles Pack, February; Two Instances of Mobility of Gold in the Solid State, by E. Keller, January.

Ball-mills and Fine Grinding, by E. W. Davis, February.

Use of Cripples in Industry, by J. P. Munroe, January; Need for Vocational Schools in Mining Communities, by J. C. Wright, January; Employment of Mine Labor, by H. M. Wilson, January; Psychology Tests, February; Mental Factors in Industrial Organization, by T. T. Read, February.

In addition to these, a number of excellent papers are still in committee.

MEETING OF THE BOARD OF DIRECTORS, NOV. 22, 1918

The meeting of the Board of Directors, on November 22, was attended by eight directors, the Secretary of the Institute, and eight guests. The proposed James Douglas Prize and Tablet was referred to a committee of eleven. Robert H. Richards was appointed representative of this Institute to attend the meeting of the Society for the Promotion of Engineering Education. J. V. N. Dorr was made chairman of the Finance Committee in place of George D. Barron, resigned.

The sum of $200 was appropriated for the 1918 expense of the American Engineering Standards Committee; the question of an appropriation for 1919 was referred to the Executive Committee for study and report. The sum of $50 was appropriated to the Treasurer's clerk.

The following representatives of the Institute were elected: W. L. Saunders to succeed himself as United Engineering Society Trustee; R. M. Raymond to succeed himself as member of Engineering Foundation Board; S. J. Jennings to succeed himself as member of Engineering Council; George F. Kunz to succeed himself as member of Engineering Council; C. F. Rand to succeed himself as member of John Fritz Medal Board of Award; E. Gybbon Spilsbury to succeed himself as member of the Library Board.

To members of the Canadian Mining Institute residing in Canada or Newfoundland, the privilege was extended to subscribe to the *Bulletin* at the price of $5. An invitation was extended to the Mining and Metallurgical Society of America to consolidate with the American Institute of Mining Engineers. The appointment of Engineering Societies' Employment Bureau was reported.

Thirty-nine members and ten associates were elected. Two members were reinstated. Extension of time for the payment of dues was granted to four members. Seventeen members on active duty at the front had their dues remitted.

A minute regarding the eightieth birthday of Past President Robert W. Hunt was passed; this is recorded elsewhere in the *Bulletin*. The sum of $50 was appropriated to the Washington, D. C., Section.

The title of the *Bulletin* was changed for one year, to read: "Bulletin of the American Institute of Mining Engineers with which is consolidated the American Institute of Metals." It was resolved that a bronze tablet be placed in the Members' Room to commemorate the American Institute of Metals.

RESOLUTION *Re* ROBERT W. HUNT ON HIS EIGHTIETH BIRTHDAY

At their last meeting, the Directors of the Institute passed the following resolution regarding Robert W. Hunt, who was president of the Institute in 1883 and 1906. This resolution was engrossed and presented to Captain Hunt at a dinner given to him in Chicago, December 9, on the occasion of his eightieth birthday.

Resolution

At that time it was announced that $5000 had been guaranteed as the nucleous of a fund, the income of which will be used for prizes to be awarded each year, under the supervision of the American Institute of Mining Engineers, for the best papers on iron and steel subjects.

The Board of Directors of the American Institute of Mining Engineers extend to their distinguished colleague, Robert W. Hunt, a hearty greeting upon his eightieth birthday anniversary. They congratulate him upon his notable achievements as a pioneer in the manufacture of iron and steel, and his long and admirable service both as a practical director and as a wise critic and counselor in that art. They remember with gratitude his successful administration, for two separate periods, of the Presidency of the Institute, and they recall with pride the honor conferred upon it through the award to him of the John Fritz Gold Medal. Not least is their satisfaction in the retrospect of forty-four years of his membership in the Institute, with its unbroken record of loyal friendship and delightful companionship; and they pray that this record may be continued for happy years to come.

In witness whereof, they have ordered this minute to be entered upon the records of the Board, and a copy duly attested to be sent to Captain Hunt.

LOCAL SECTION NEWS

WASHINGTON, D. C.

HERBERT C. HOOVER, *Chairman*
H. FOSTER BAIN, *Vice-chairman* DAVID WHITE, *Vice-chairman*
HARVEY S. MUDD, *Secretary-Treasurer*, Room 2114, Dept. of Interior Bldg.
J. F. CALLBREATH HENNEN JENNINGS E. W. PARKER T. T. READ

An inspiring meeting of the Washington, D. C., Section was held at the Cafeteria of the Interior Building on Friday evening, Dec. 6, 1918. One-hundred and thirty-five members and guests attended, and Vice-chairman H. Foster Bain presided.

The Committee on Nominations reported: for Chairman, Herbert Hoover; for Vice-chairmen, Frederick G. Cottrell, and F. L. Ransome;

for Secretary-Treasurer, A. G. White; for members of the Executive Committee, Anthony F. Lucas, Chas. Catlett, Paul D. Merica, and Frederick W. Wood. These officers were unanimously elected. The following addresses were then delivered:

RECONSTRUCTION PROBLEMS

BY M. F. CHASE

Explosives and Chemical Division, War Industries Board

When I was first approached in regard to writing a paper on the subject of reconstruction problems it was generally thought that the work of getting the industries of the country back into peace time production would disclose the necessity of many changes in existing methods of conducting commercial business and of a readjustment of many of the heretofore established relations between government and industry and between capital and labor. At the time the armistice was signed at least fifty per cent. of the industries of the country were devoted to war work and at least thirty per cent. were doing nothing else. The world's shipping had been reduced and restricted and the former peace time trade routes had been disturbed and many of them eliminated. It was believed impossible to revert to commercial lines without serious complications, and, further, that the war itself had changed the status of commercial relations to such an extent that at the cessation of hostilities a new era would be commenced in which the old established methods of business would have to be completely readjusted in order to find markets for our products and raw materials for our factories. Numerous changes in laws were suggested as necessary to permit of the proper growth of industries under the new order.

This idea grew largely from the fact that in the European countries there are true reconstruction problems and questions, which have, during the last two or three years, been studied by commissions or committees acting under the immediate direction of the respective governments. Thus, as early as May, 1916, France was compelled to take up the question of rehabilitating her invaded and devastated territory and of credits to aid in the resumption of agricultural and industrial life. Somewhat later, Great Britain established a Ministry of Reconstruction, which has organized eighty-seven committees and commissions, each studying some particular problem which England, because of her economic dependence on other countries, must solve after the war. In October, 1917, Belgium, faced with the same conditions as France, created a Ministry of Economic Affairs, under which rehabilitation problems are being investigated and worked out. Italy, too, has established a Ministry of Economic Reorganization. Similar studies have been undertaken, to a greater or less extent, by Canada, Russia, Japan and other countries, both in Europe and in South America. Germany appointed a commission on economic transition early in August, 1916, and numerous commissions on economics were thereafter formed. The fact that the commercial and governmental interests of these foreign countries considered reconstruction problems so vital, naturally led the same interests here to think that the United States would also have the same questions, probably differing in degree, to meet and solve.

As time has gone on, however, since the signing of the armistice, now almost a month ago, it is becoming more and more evident that we do not have in this country the problems that are confronting the European countries, and that we are very rapidly going back in many industries to peace time and commercial production without the disarrangement of business that was thought bound to occur. This in part is no doubt due to the fact that we had only partly converted the country to a war basis and we had been in the war for a much shorter period than our associates abroad. It is also partly due to the fact that our business methods have been such as to lend themselves more readily to quantity production of war material than those of the foreign countries. We have proceeded with the production of war materials along the lines of well established American business principles, and it has not been necessary for us, in order to meet the necessity created by war of large additional supplies, to change radically our methods of production or our methods of factory management. Consequently, as we go back to the production of commercial articles we have but few changes to make in our industrial and in our political system. It is, of course, inconceivable that the business of this country should be turned so completely and within such a short time to the production of war materials without bringing quite forcibly home to us some of the defects that have existed in our system. The correction of these faults and defects in our business and political system cannot be considered reconstruction problems, but are political and economic problems, the proper

solution of which must come from careful study and consideration of the rights and interests of all involved. In most part they are not new problems at all, but have been discussed at length in the past. They have simply been emphasized during the war, and the operation of war work has given us data and experience for a better solution of them. It is quite important that these questions and problems should not be confused with true reconstruction problems, which, from the very necessity of things, must be solved within the immediate future, as the time of reconstruction is limited. On the other hand, serious errors may result from too hasty a consideration of questions, the solution of which may involve a fundamental and radical change from our former established order. In the minds of some who have written on this subject, it would appear that every mooted question of political and economic policy should now be brought forward as a reconstruction problem which must be solved before the country can get back to a normal basis. In this list have been included questions of the regulation of public utilities, conservation of natural resources, tariff regulation, questions involving changes in financial system, foreign trade, changes in foreign consular service, public ownership of utilities, educational problems, modifications of trade laws, regulation of industries, relations between private capital and labor—in fact, almost every question of government or economics has had one or more champions earnestly pressing it as of the utmost importance to be solved and corrected at the present time. When one analyzes the situation, it will be seen that actual reconstruction problems are extremely few. They do embrace, of course, the disposition to be made of the railroads, steamship lines, express companies, and telephone, telegraph and cable lines, all now under government control. They embrace also the disposition to be made of war risk insurance policies and certain matters of finance and taxation, but with these exceptions it is doubtful whether there is any problem at all of such pressing need for solution at the present time as to warrant classing it as a real reconstruction problem in this country.

The question that probably gave the most immediate and deepest concern was that involving the cancelation of contracts for war materials. An unsound policy in this connection might have led to a world of complications both financially and industrially, but this matter at the present time has proceeded to such an extent that we may almost feel sure that complications and troubles which we thought would arise will not come to pass, and that, aside from legislation that may be required to permit of the application of certain sound and equitable principles laid down by the different war purchasing departments, the problems involved in this question will automatically solve themselves. In this particular connection, provision has been made by the War Department and other contracting agencies of the government for a fair and equitable adjustment on all war contracts, and many of the large war contracts are already in the process of liquidation, and the demobilization of war labor is proceeding in an expeditious and orderly manner without undue hardship either to the labor or to the industries involved. There is but little doubt that as the readjustment proceeds abroad and the industrial and commercial life of the foreign countries is reëstablished, we will have to modify or change our methods and practices to competitively meet the conditions established abroad. It will be idle to think that in meeting these we will not have to radically change the existing order of things here in certain respects, but it would appear equally ineffective to attempt at this time to meet conditions that we and everyone else are ignorant of and can only guess and theorize upon. In most part, the plans for reconstruction in the countries abroad have been based on hypotheses that may or may not be true in fact, and it is inconceivable that plans founded in this way will not have to be changed or abandoned as the true conditions are discovered, and in attempting to meet these conditions the wisest plan on our part will be to keep fully and completely advised as to what is actually happening so as to be able to act quickly and intelligently to meet each situation as it develops.

American institutions are not bound up and hampered by traditions and precedents, and we have the freedom here to act as soon as we are in possession of the facts and have a knowledge of the conditions that we will have to meet. At the present time, the greatest service would be the establishment of such agency as will promptly and accurately give to the country full and complete information on the different situations as they arise, rather than devote time and energy to the solution of problems that are not certain really to exist. The correct statement of any problem goes far toward solving it. Our post-war problems, for the most part, cannot be clearly seen and stated now. They are still in the development stage. It would only be a fortunate guess that would visualize them correctly at this time. To know what they really are, we must first know the terms and conditions of peace.

Let us, therefore, be not too hasty in proposing reconstruction measures. Possibilities only surround us now. We cannot build on them. But the future will

develop what the realities are. Let us await them with minds that are open and calm and ready, confident that the American people, possessed of the spirit of coöperation and sound business judgment and foresight, will solve the industrial problems of the future as surely as they solved the military problems of the past.

PEACE AND FOOD

BY EDGAR RICKARD

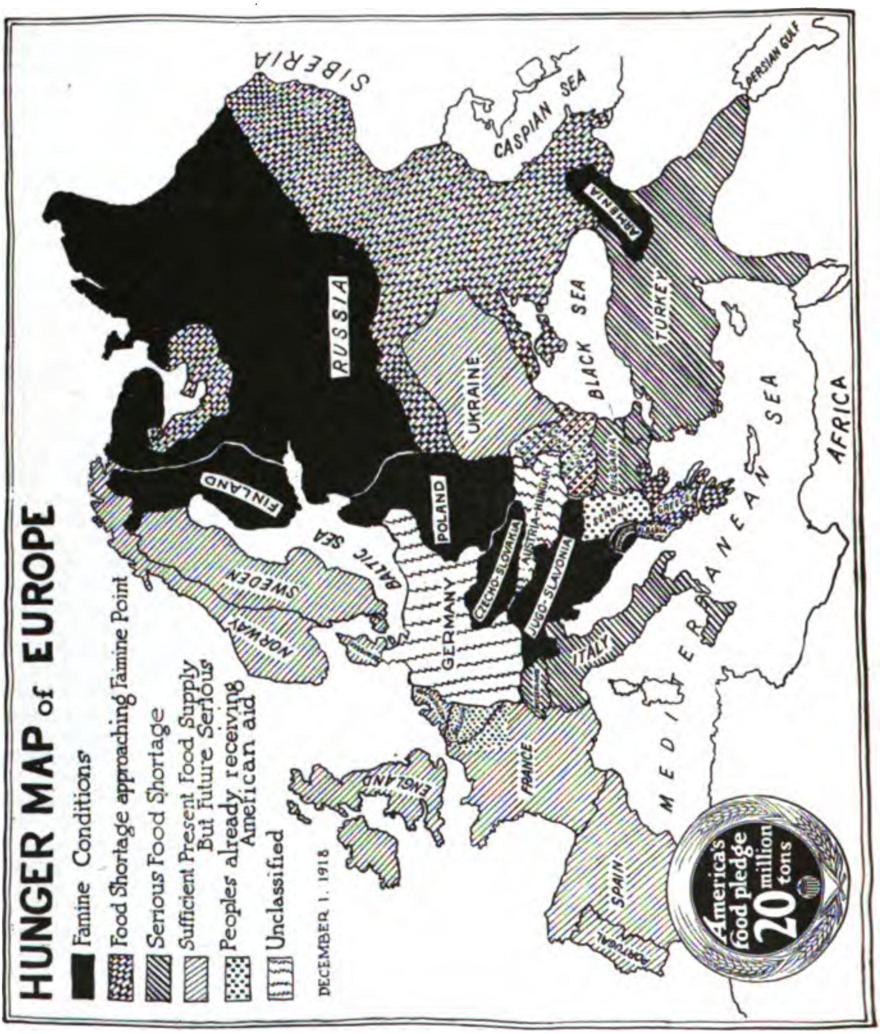
U. S. Food Administration

I did not select the title for my remarks this evening, that is, "Food and Peace." In fact, I doubt whether the Food Administration will give the American people any peace on food matters until each and every one of the nations in Europe have been able to assume normal conditions. To appreciate the European position, we have made a rough map which we call the "Hunger Map of Europe." From this map you will note that the conditions vary all the way from famine conditions in Russia to the position of England and France with sufficient food for the time being but requiring their stocks replenished at the earliest possible moment. There seems to be an impression prevailing that there is no necessity for helping these people because from all reports there is no actual starvation. This is an absurd stand. Take the example of Belgium, in which our American people have been most interested, where it has been a question of near-starvation for the past four years, and during that entire period our efforts have been largely aimed to prevent starvation. If we had waited until starvation had actually taken place, it would have been impossible to transport food in time to avert wholesale death.

When Mr. Hoover formed The Commission for Relief in Belgium on the 22d day of October, 1914, there was no starvation in Belgium but conditions were rapidly tending in that direction. The Commission for Relief in Belgium had absolutely no funds, but Mr. Hoover and his associates arranged immediately for the purchase of supplies to the extent of $10,000,000, pledging their own credit and counting on the goodwill of the benevolent world to see that these bills were paid, and nine days later the first food went over the border into Belgium. A similar condition has now presented itself. Immediately after signing the armistice, the President directed Mr. Hoover to proceed to Europe in order to study the food situation and to report to him as to what part the American government could play in relieving the situation. There was no doubt for a moment but that Europe must consider the United States as her pantry, at least up to the time of the next harvest. Mr. Hoover did not wait to arrange for finances but immediately delegated a committee of the Food Administration to arrange to ship 270,000 tons of food representing probably $54,000,000 in value, to the Mediterranean ports and the northern ports, consigned to him for his allocation. Up to this moment the details for financing this work have not been arranged, but we do know that the first ships on this program have already passed Gibraltar into the Mediterranean. The question before the American people is not as to how these arrangements are to be made or how the government will finance the operation, but as to where the necessary food is to be obtained. In 1917, the United States shipped a little more than 5,000,000 tons of food to Europe. By special conservation drives last year we were enabled to raise our shipments to 12,000,000 tons. This year we propose to ship 20,000,000 tons and from practically the same resources, for while the wheat crop is greater than last year, the other cereals are not so abundant and the chief factor of shortage is that of pork and pork products including all fats. This figure of 20,000,000 tons represents the absolute limit of cargo capacity of our own ports and it means that every stevedore, every wharfinger, every dock, and every seacoast elevator will be working to its full capacity in order that we may fulfill this program, but to the American people as a whole it is a matter of saving from their tables sufficient food to allow us to carry out this program.

A general program of saving is most difficult to effect. The Food Administration has found no difficulty in putting over the special drives, but we have found that these special drives were dangerous in the extreme in that our good people went far beyond any regulations which we attempted to enforce. To give you an instance, when the sugar restrictions were placed on our people, it was calculated that at the rate of two pounds per person per month, we would be able to hold even on our stocks and come through with a safe margin of sugar in January, but instead of saving two pounds per month, the householders went further with the result that out of a normal consumption of 4,000,000 tons per annum, our people saved over 700,000 tons of sugar by conservation. This put us in the position of having more sugar on hand than was actually required at the moment and resulted in lifting the restrictions from two to three pounds per month, next from three to four pounds, and now our restrictions

are removed. You can see from this that the special drives rebound against us because our policy has always been to take the country into our confidence and give them the benefit of the stocks which we have on hand, and this has meant that we have been obliged to constantly change our rules almost from week to week, causing great confusion and unwarranted criticism. This ready response of the people is due to their absolute belief in the fair play and integrity of our chief, Mr. Hoover, and we must maintain this confidence which has been so well earned. We realize that it is



not only difficult to outline a general thrift program but it is difficult to enforce it, but we rely upon the intelligence of the American people to meet the request we are making for general conservation in order that we may carry out our obligations to the countries abroad, particularly those so recently released from the bondage of German and Austrian occupation. We want to see all of that portion of the map which is black now and which is rapidly approaching the famine condition, changed to the shaded condition indicating that they are on the road to normal food supply.

It seems to me that a gathering of engineers would be interested in a review of the history of the organization which Mr. Hoover, as a mining engineer, has set up in order to control our food conditions in America. The Commission for Relief in Belgium,

which as a matter of fact, gave birth to the Food Administration, originated in the appeal of a mining engineer, Millard K. Shaler, who came over from Brussels to London in September of 1914 in order to secure some $200,000 worth of food to relieve immediate distress in Brussels. He was backed by Emile Francqui of Brussels, who has for many years been prominent in Belgian mining interests, not only in the Far East but as a prime mover with the Guggenheims in the Congo in starting that interesting venture, "Société Internationale Forestière et Minière." Curiously enough, this same Mr. Francqui who has headed the Comité National (the Belgian partner of the Commission for Relief in Belgium) was associated with Mr. Hoover some years ago in mining in China. Shaler was unable to secure the immediate relief necessary and it was my particular pleasure to introduce him to Mr. Hoover, who immediately took hold, as I have recited earlier in these remarks. The nucleus of the Food Administration was made up of men from the C. R. B.

We opened offices with three rooms in the Willard Hotel in May, last year. In two weeks we accepted the generous offer of Mr. Otis Smith, Director of the Geological Survey, to occupy certain unused rooms in this building (Dept. of the Interior). I am afraid that we overdid our hospitality, as we simply overran Mr. Smith and occupied much more space than he had originally intended to allocate to us and we have often wondered whether Mr. Smith realized how he saved our homeless organization at a time when we were perplexed as to where we could be quartered. From the three rooms at the Willard, we have now grown to occupy two large temporary buildings with a floor space of 150,000 square feet, and in July our force in Washington numbered close onto 2000 and our force in the field nearly 6000, making in all 8000 people. You will be interested to know that this organization has been operated without an office chart. As Mr. Hoover's staff grew, each new member in turn advocated an office chart or what we would call in metallurgy, a flow sheet. No one thought we could proceed without an official guide designating each man's title and position. While Mr. Hoover was in policy very much opposed to any such departmentalization, he listened to the arguments but was able in each case to show that his method of organization would meet the conditions which presented themselves, and his method of organization is a very simple one. He considered that the whole problem of food control was a new one without any precedents to work on. It was impossible to pick men equipped with experience in this new work, so he selected for his staff men of intelligence, and to each one he delegated a problem for solution. It was stipulated that in solving this problem the associate who had it in hand could consult freely with the other men and as a result of these conferences four policy boards came into existence almost without our knowledge. The Boards discuss the policy concerning the particular industry with which they have to deal and pass up their final decisions for Mr. Hoover's approval. On top of this we have an executive board which only functions during Mr. Hoover's absence from Washington. I particularly desire to mention this matter of organization because I believe that it is unique in government practice and I leave it to you as to whether it has effected its purpose.

Now of the 8000 people who are enrolled in the Food Administration and giving the whole of their time to the Food Administration, there are over 4000 volunteers, and these volunteers are giving up the whole of their time, paying their own expenses, and receiving no remuneration of any kind from the government. Of these there are 3019 County Food Administrators. As a matter of interest (because we sometimes like to put things in dollars and cents) figuring on the basis of what the government pays its Bureau Chief and other officers, if these volunteers were paid the regulation government salaries, the Food Administration would cost the government something over $9,000,000 per annum over and above our present payroll as against a total annual appropriation of $7,500,000.

Before the war, those of us who lived on the other side know that our country did not have any too good a reputation. I do not say we were thought dishonest, but at any rate we were thought capable of committing sharp tricks. You will recall that constantly repeated tale of some Connecticut Yankee who sold wooden nutmegs in place of real ones. They held that up as the standard of our business ethics. During the last eighteen months they have conceived an entirely different idea of America. It started without charitable efforts. Our reputation was helped greatly by the Belgian relief, and then came the war, and the wholesale way in which we applied ourselves, and in which we made no bones about giving up absolutely everything in order that the war might be won. Now with the changed conditions and the boys coming home, there is some danger of our letting up and rushing over to the other side, taking advantage of the conditions and making money out of their unfortunate position. I believe this should be prevented and I think it can be by organizing all of the relief, as far as food is concerned, under one responsibility with

reconstruction and rehabilitation under one head—to have it all flow through one channel and to have all the finance go through one body; to set up a body similar to that which we have in the Food Administration which we call the "Coördination of Purchase Division," which would allocate our food products for Europe. To give you an idea of what this means in the Food Administration, we handle all of the food purchases for the Allies, we handle all the food purchases for the Army and Navy, for the Belgian Relief and for the Red Cross, a matter of $600,000,000 per month, and I don't think anyone has ever had even an intimation of scandal as to the food supply of our fighting forces. We do not actually purchase this food, but when we receive a requisition from the Allies or the Army or the Navy, we tell them where they can get this food. If they want condensed milk we can meet their requirements from California or Oregon if it is desired in the west, or if it is desired in Chicago or on the Atlantic coast we meet the requirement from some nearby point. This Administration has allocated all the food purchases made in America during the last year and we feel that just such an organization should handle our trade abroad. I do not see why it would not be a great benefit to our own merchants. It would stabilize prices and eliminate all the cost of competitive selling and we would be able to determine prices by consultation with the trades as the Food Administration operates now. I am not able to say whether this will come about. It is almost too Utopian to think about but I do think the American people today are idealistic enough to see such an immense organization put through, and put through by a man whom we all love, and that is Mr. Hoover.

SOME INTERNATIONAL FEATURES OF THE MINERAL SITUATION*

BY C. K. LEITH

Mineral Adviser to Shipping and War Industry Boards

C. K. Leith first outlined briefly the relation of mineral raw materials to a possible league of nations, and then added: Any economic scheme of international control concerns principally the exportable surplus and necessary imports, and not the raw materials consumed within the country of origin. It involves essentially the allocation of exportable surplus by mutual agreement to accomplish various purposes—to insure that all are supplied, that no one nation gets too much, that the supply for enemy countries be controlled, that no one nation uses more than its share of the world's limited shipping, etc. Any such allocation involves some curbing of the richer and stronger nations. In regard to minerals, the sacrifice of the United States would be relatively greater than that of any other country, for in minerals we are well able to take care of ourselves in unrestricted competition for world trade because of large and varied resources. One of the consequences of an agreement to control exportable surplus should be the abandonment of the slogan that the United States should make itself entirely independent in regard to all raw materials even at high cost and with the aid of protective tariffs. From the standpoint of conservation of certain minerals in which our supplies are limited, and in the interest of the best use of the world's supplies by all countries, it is not in general desirable to set up artificial barriers to international reciprocity in regard to minerals.

Mr. Leith then cited arrangements for international control of certain minerals already in effect and indicated the minerals of the United States which would be most affected by any general agreement to control exportable surplus. He concluded that the difficulties involved in controlling international movements of minerals are many and serious and would weigh heavily on the United States, and that it is doubtful whether the United States is ready for this degree of sacrifice of national self-interest for the larger good, but urged the necessity of striving for better international arrangements of some kind for the common use of mineral raw materials.

Mr. Leith closed with a plea for a more comprehensive study of world mineral statistics and problems by the Department of the Interior and non-official organizations and technical papers.

PETROLEUM AND RECONSTRUCTION PROBLEMS

BY CHESTER NARAMORE

Petroleum Technologist, U. S. Bureau of Mines

I am happy indeed that the American Institute of Mining Engineers has recognized this field of technical research and general engineering endeavor in the creation of the Committee of Petroleum and Natural Gas with a splendid chairman, that real patriarch among petroleum engineers, Captain Lucas.

*This address will be printed in even greater detail than it was delivered, in the orthcoming volume of Mineral Resources of the United States (U. S. Geol. Survey).

For the past several years the United States has been producing each year approximately 65 per cent. of the world's production of crude petroleum, reaching the high figure of 335.000.000 barrels during 1917. It is also a noteworthy fact that of the total world's yield the United States has produced about 60 per cent. These figures will point out to you the commanding lead we have established in the production of petroleum. In 1917, Russia was our nearest competitor, with a production of 14 per cent., while Mexico, which is now considered the bonanza of the oil world, furnished only 11 per cent. of the world's output.

Just as we have held the lead in the production of petroleum, so have we been to the fore in advanced methods of producing, refining, and transporting. In the realm of research I know of no laboratory facilities superior to those in use in this country.

In general, such was our lead in the petroleum industry upon the entrance of the United States in the war, and it was obviously apparent at that time that the industry would be called upon for many and varied demands, which were met by the operators and refiners in a most willing spirit.

The American petroleum industry was very prompt in organizing on a war basis and it is indeed a pleasure to be able to report that it met every war requirement to the limit of transportation facilities and storage equipment overseas. Through the efforts of the National Petroleum War Service Committee the various units, commonly classed as the "Standard Oil Group" and the "Independents," were able to form an efficient working organization. At a later date Mr. Requa was called upon to organize the Oil Division of the United States Fuel Administration. He did so by gathering around him a staff of representative and able oil men. These two agencies representing the industry and the government were able to organize matters so efficiently that the very great needs of the Allied and American forces for petroleum products overseas were fully met and this was accomplished with the minimum possible disarrangement of the domestic requirements. Such a tremendous task was made possible by the closest kind of coöperation on the part of all units of the industry and the government.

It involved a strenuous campaign to obtain a maximum production of crude oil, which in turn meant the securing of necessary priorities for casing and drilling equipment. The pipe-line deliveries were speeded up and greatly increased efficiency was secured in tank car deliveries. Refiners coöperated in furnishing the special products needed for war purposes. The natural gas industry was similarly organized and both industries and the consuming public were asked to assist in the institution of a very comprehensive campaign of conservation.

As a result of this, and the two years of working together, it is now equipped better than ever before to make a most efficient commercial utilization of its entire equipment and resources, because of better coöperative effort and increased tonnage of tank steamers. It is interesting to note that our tanker tonnage shows a gain of about 50 per cent., since early in 1917, with a gross dead weight of 1,360,000 tons on November 15, 1918. This is fortunate because there will be an increased demand for gasoline and lubricants for internal combustion engines both at home and abroad. Such a statement is based upon general observations of very greatly increased utilization of internal combustion engines, and on the extent that petroleum was utilized in winning the war.

The wonderful service which petroleum rendered to civilization in the war cannot be grasped in a moment, nor be understood by one not familiar with the extent that it served as a medium of locomotion for the vast armies and the overwhelming tonnage of munitions and supplies which had to be moved to maintain the armies in action.

As a source of power it functioned in all of the important mechanical contrivances that stand out as important factors of the war, whether on land, water, or in the air. Eliminate petroleum and you would have eliminated the submarine, the fast destroyers, the best battleships, the auto, the tractor, the tank, the motor ambulance, the motor truck, and the aircraft. What a stupendous contribution to modern warfare!

The airplane, the submarine, and the tank, each stands forth very clearly in the average man's picture of recent great events. But, to those whose duty it was to supply the fuel, it is clearly evident that the humble motor truck functioned to an extent not measurable in any but superlative terms.

Trucks, trucks, and more trucks, ever present from the channel ports to the Adriatic, constituting a main artery that carried the life blood of the armies, whether in men, munitions, or supplies. This applies directly to reconstruction problems, because it means when the troops return the greatly increased use of the motor truck for every conceivable future transport problem both in Europe and America; yes, and in South Africa and Australia.

Previous to the war, apparently the only limit to the number of motor cars absorbed by the public was the number which the automobile industry could build. The motor truck, on the other hand, had proved its worth most conspicuously in our commercial centers; the millions of men across the sea who represent the best blood of each nation have become accustomed to depending upon the long trains of motor lorries for their every want. Accordingly, when they return home they will automatically think of transport problems in terms of truck loads as well as tons.

Consider this universal use of trucks with the unrestricted manufacture of automobiles, and the problem from an engineer's point of view becomes one of unlimited road building. Good roads, with permanent bridges, and new regulations as to road maintenance and repair must materialize. In fact, it means a complete revolution in the attitude of many communities toward expenditures for roads that will stand the traffic wear of fast moving 4- and 5-ton (and even larger) trucks. Many of the so-called permanent highways, of which certain states are so justly proud, are permanent only in a relative sense and even though they represent expenditure of millions they will not be found serviceable for severe freight transport. I will let your fancy picture the further problems immediately ahead in the fields of engineering, financing, and maintenance.

Tractors are merely another branch of the one great field of automotive endeavor and their more extensive use is an assured fact. Their successful adaptation to farm use will spread with increasing rapidity as the knowledge of the internal combustion motor becomes more and more general.

I will leave the possible extensive development of the aircraft without comment, except to remind you that in Britain, France, Italy, and our own country the building of internal combustion engines of various types has been intensified to a degree second perhaps only to the manufacture of guns and munitions. Accordingly, if the skilled labor and equipment needed for their manufacture is available, internal combustion engines will be built in ever increasing numbers, and the fuel at home and abroad must be provided to operate them.

Turning, for an instant, to the future demands of fuel oil, your attention is called to the fact that during the past summer the fuel oil problem has been the cause of as much or more worry to Mr. Requa as the supply of gasoline, but much of that supply was for strictly navy use, so for the time being the fuel oil situation is much easier, but the improved condition is for a period only. This demand will undoubtedly increase when a great number of the merchant marines now on the ways are put into service. It is not necessary to dwell upon the advantages of oil over coal as a fuel upon the seas. For instance, it is much easier to handle, requires less bunker space, a smaller complement of men, and also enjoys a great many other advantages with which all of you are familiar.

To guarantee the perpetuation of the several tremendous industries in which the internal combustion motor functions, including automobile trucks, tractors, motor boats, and aircraft, an unlimited supply of petroleum is a basic necessity, and to further guarantee the life of the above industries a campaign for the conservation of petroleum products should be continued and needless losses should be prevented.

The popular conception that there will be a permanent decrease in the demands of petroleum after the signing of peace is erroneous. Bear in mind for a moment that in France and England for the past year every gallon of gasoline used has been for war purposes, and every day was a gasolineless day. With the lifting of this ban undoubtedly any surplus of gasoline will be readily consumed by the civilian population.

Coming now to the fourth point under consideration, namely, the suggested means of maintaining our lead in the petroleum world, we are at once confronted with the problem, how will the industry meet the future demands for petroleum? A great many men have predicted in the past that each year the maximum production would be reached, and it seems very obvious to those who are close students of the game that we cannot expect any material increase in production over that of the present year, 1918. To our best knowledge, outside of Northern Texas, certain parts of Oklahoma, and Wyoming, the oil fields of the United States have been explored to a very large extent. Optimistically assume that the production will remain constant for the next several years, and assume that consumption will not increase for the next few years. How then will we make up the deficit of 52,000,000 barrels as of 1917, 21,000,000 barrels of which were drawn from storage and 31,000,000 barrels imported from foreign fields, chiefly Mexico.

With such a shortage and no probable increase in home production, it is very evident that to meet the shortage we must first of all obtain from petroleum a maximum recovery and a minimum loss. Extensive research work should be carried on

in order to improve the art of producing, storing, shipping, and refining of petroleum, and to develop possible unknown and better uses of this wonderful natural resource that it might still further serve mankind.

Most of you readily recall the time when a young mining engineer was about as welcome at a mine or mill as a Prussian General will be in Paris, but a great change has taken place and the engineer is now an integral part of the mining industry, thus permitting the technical man and the practical man to join forces in perfect accord to solve any new problem met with in the day's work. Moreover, through the agency of numerous technical journals and societies, such as the American Institute of Mining Engineers, the mining man has for many years been a true socialist in the whole-hearted manner in which he has coöperated in sharing his knowledge with the mining world. The results of such a generous policy have been manifested in the truly marvelous accomplishments of the mining industry in the last several years.

The societies for the exchange of technical information are comparatively few and poorly organized, and the journals representing the industry are generally speaking strictly trade journals and with few notable exceptions seldom attempt any technical discussions, not wholly as a matter of policy, but because of the fact that few articles of merit on petroleum engineering problems are available. This is not intended as a criticism, but a blunt statement of existing conditions, in order to bring to your attention the fact that a wonderful field for research work exists in this great industry in all of its various operations from drilling to refining.

In defense of the industry as a whole, I must make clear to you that there has ever been a much greater incentive for individuals and companies to keep their information as a trade secret than in the mining industry, because of the keener commercial competition between companies, in fact the early history of the petroleum industry is recorded as an era of unrestricted business warfare.

Oil Shale.—It has been suggested by a great many writers that oil shale will solve the problem of the world's demands, but we should bear in mind that this industry is in a decidedly experimental stage with need for extensive research work. The solution is not a simple one when we consider that on a basis of a barrel of oil to a ton of shale, 1000 barrels of crude oil output per day requires on the roughest kind of an estimate an initial investment of approximately $1,000,000. It is primarily a moneyed man's undertaking and with such heavy initial expense its development will be very slow. Hence we can not look upon the oil shale industry as a solution of our nation's needs within the next few years. This industry has its place, of course, in the American problems and I do not intend to minimize in any way the attention that should be given to development of oil shale.

In spite of our very best efforts for conservation and a maximum recovery from the oil produced, it is very evident that this country must in the future depend upon foreign fields to meet a considerable part of the demand that will be made.

Moreover, because of the universally recognized importance of petroleum as a prime factor of national defense, we must expect every first class nation to endeavor to control as much crude production as possible, in order that they may be less dependent upon the United States. In view of this, I would consider it little less than a national calamity if American capital should fail to develop the potential petroleum resources contingent to the Gulf of Mexico, the Carribean Sea, and those of South America.

The control of the crude oil production of the world is often thought of as a battle between giant corporations, one in America and the other a Dutch-British unit, but the control means more than division of profits between rival business concerns. It means fuel, and fuel is power and national security as well as prosperity.

It is true that our domestic production has been able to supply two-thirds of the world's consumption, but petroleum is a wasting resource and in this country, because of its accessibility and proximity to industrial centers, we have already drawn heavily upon our total supply as we approach the dawn of a tremendous era of petroleum expenditure.

With the facts as outlined in my earlier remarks thoroughly known and appreciated by the powers of Europe, it will indeed be surprising if every encouragement is not furnished the different representatives of the petroleum industry by their respective governments to extend their holdings the world over. This assistance may even assume the form of active government investment in petroleum reserves.

Accordingly, with American interest thoroughly intrenched in the prolific fields of Mexico, it is to be earnestly hoped that they will not find it necessary to sell to foreign capital, but will be able to further increase their holdings in these fields, which are so accessible to the States.

Furthermore, if the tremendous effort of this country to establish a merchant marine is to bear its maximum rewards, the ships must be provided with oil from

nearby sources to reduce the long haul cost. To this end it would be well if American capital did not limit its activity to this hemisphere, but participated in exploration and development work even to more distant parts of the globe.

Nationally speaking, it is a question to ponder over, when one considers that American geologists are locating prospective fields and American drillers are developing petroleum reserves the world over FOR FOREIGN CAPITAL. May I leave that one thought with you as of first importance.

Bradley Stoughton, Secretary of the Institute, then said a few words of greeting and congratulation, and the meeting adjourned.

HARVEY S. MUDD, *Secretary.*

SAN FRANCISCO SECTION

ROY H. ELLIOTT, *Chairman* T. A. RICKARD, *Vice-chairman*
W. H. SHOCKLEY, *Secretary-Treasurer*, 959 Waverly St., Palo Alto, Cal.
D. M. RIORDAN C. F. TOLMAN, JR.

The special meeting of November 11, held at the Engineers' Club in San Francisco was attended by 30 persons and was special in a double degree; first, it was specially called to meet President Sidney J. Jennings; second, a special permission had to be obtained from the Board of Health, which was granted with the proviso that we should omit our usual dinner and wear masks. This mask-wearing was based on a city ordinance, passed in the last days of October to combat the influenza. More than 12,000 persons were arrested for failing to comply with this law. In all, 1857 persons died from influenza, but as far as I know none of our members died.

Roy H. Elliott, the chairman, announced that he had appointed a committee of four members to act with similar committees from the American Society of Civil Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, and the American Chemical Society, these organizations, together with the Institute, forming the Joint Council of the Engineering Societies of San Francisco and working coöperatively, but not amalgamating. This Joint Council intends to hold five meetings during the coming year, all separate from the meetings.

The address of the evening was made by President Jennings, who said that the Institute had recently helpt* to pass the War Minerals Bill. Some have criticized the Institute for going into politics, but he did not consider that aiding the passing of this bill was political activity; rather it was an effort to aid the mining industry. The Government needs to be stimulated so that it will extend more aid to mining; for while agriculture, which is called the basis of life, receives great sums, little attention is paid to mining, the basis of civilization. Valuable aid is given to the farmer by the many publications of the Agricultural Department, but the Bureau of Mines and the Geological Survey are obliged to struggle for appropriations. The War Minerals Bill increases the amount of money available for the mining industry, but the method of administering the bill has not yet been workt out. Now that the war is over, it is impossible to tell what will be done, but the intention was to make in-

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* Reformed spelling retained by special request of the Secretary of the San Francisco Section.

vestigations and enter into contracts with producers for a stated quantity at a fixt price which would continue for a year after the conclusion of the war.

The Institute realizes the importance of the local sections, and the importance of the getting together with the sections of the four other national societies. If the sections should meet once or twice yearly there would be from four to eight yearly meetings, a result that would be welcomed by the heads of the societies in New York.

The Institute is essentially a forum for presenting and discussing ideas. One of the chief subjects for discussion is human engineering. Engineers study the use of materials and mathematics, but they do not study what is fully as important—the human factor. The old way of looking at the question was that we bought labor; now it may be said that we sell employment; our salesmanship, which is not of the best, ought to improve. Formerly the capitalist has had the say as to what should be produced; in future the responsibility must be shared with the man who can control labor; only by the union of the two can wealth be economically produced. The public (that is the customer) is vitally interested in seeing that the science of social bookkeeping is thoroughly learned and the charges accurately kept. Labor leaders have argued that because all wealth is produced by labor, labor should have the entire product. This specious argument omits to take into account the fact that labor must be directed. As captains and officers of the army of labor, we should direct it and satisfy its demands. If we sit down and talk to labor its demands seem reasonable. Legislators are, in a way, the auditors of social bookkeeping and have shown themselves responsive to labor's needs by passing such bills as the workmen's compensation and the eight-hour law. If our social bookkeeping shows that a profit cannot be won from any natural resource except by debasing labor, if labor cannot live and bring up its children properly, then it is better that such natural resource should remain undeveloped. We mining engineers will be the directors and captains of labor and it is our duty to reconcile labor and capital. It is the function of the Institute to ask every member who has had experience in amicably settling labor troubles to give us the benefit of his experience, so that it may serve as a guide in the settlement of other age-long differences.

The topic of the day is the change in the purchasing power of gold. In South Africa, out of 49 mines on the Rand, 22 are producing gold with a working-profit of but 30 cents per ton; a margin so small that if wages advance the mines must close. The fact that the United States can take an ounce of gold and issue $240 in bonds on it at a less rate of interest than if it did not have the gold shows the extreme desirability of having a gold production; gold is the most powerful of credit instruments. The gold miners of the West and of South Africa have askt for a bonus on new gold; this request is opposed by certain economists who hold that the more gold, the higher the cost of commodities, and maintain that a small amount of gold will bring low prices. Prof. Irving Fisher proposes to stabilize prices by changing the amount of gold in the dollar. It is evident that the decrease in the purchasing power of gold must lead to a diminution in production, for the miner wil not produce gold in large quantities unless he can make a profit. If the Government desires more gold it should: Remit the excess-profit tax, because there has been

no excess profit in gold mining; give priority in supplies; pay a bonus of at least $12 per ounce in order to put gold mining on a pre-war basis. If it is desired to stimulate the production of gold, a larger bonus should be given. The Allies and the United States produce 93 per cent. of the world's gold and the gold standard must be preserved. If the Government could tell us how much gold is needed, we could then tell how much the bonus ought to be. In concluding, President Jennings stated that the Institute was in no way responsible for his opinions.

In the discussion that followed, Charles Butters askt what had been the action of the Chamber of Commerce at Johannesburg and of the British Government. President Jennings answered that 22 mines were found in need of relief. Mr. Butters understood that the British Government proposed that if all the mines would contract to sell all their gold to it for 10 yr. a bonus of $2.50 per oz. would be paid. Mine owners have recently been askt to subscribe a small sum for propaganda. As a producer of gold in Nicaragua and San Salvador, Mr. Butters was especially interested in this proposal of the British, since it would affect gold producers the world over and would put paper money at a discount. T. A. Rickard askt F. W. Bradley if a bonus of $2.50 per oz. would suit the mines of Juneau. Mr. Bradley thot that a larger bonus was needed, but believed that the agitation in Johannesburg would help to solve the question. Mr. Butters felt that the British had been clever in getting the price of silver put so low as $1 per oz. Chairman Elliott thot that it was hardly just for the Government to prohibit the export of gold and still maintain the pre-war price when gold could be sold at a heavy premium in Spain and other neutral countries where exchange is against us. President Jennings said that this would be equal to a premium of from 16s to 20s per oz. Mr. Butters was sure that the purchasing power of gold and silver wil increase; the Germans and the Russians wil be anxious to see some real money.

W. H. SHOCKLEY, *Sec'y-Treas.*

NEW YORK SECTION

ALLEN H. ROGERS, *Chairman*, FOREST RUTHERFORD, *Vice-chairman*,
H. C. PARMELEE, *Vice-chairman* and *Treasurer*,
W. S. DICKSON, *Secretary*, 71 BROADWAY, NEW YORK, N. Y.
J. E. JOHNSON, JR. F. T. RUBIDGE S. H. BALL.

The December meeting, held at Machinery Club, on December 11, was the best attended this year, 100 being present. Illustrated talks on the ore deposits and mining methods of the Chile Copper Co. were given by Waldemar Lindgren and L. K. Rourke. Mr. Lindgren spoke of the geology of the country, but particularly of the company's mining property at Chuquicamata. Mr. Rourke described the new departure in steam-shovel operations, the exceptional methods of blasting, and the railroading to the mill.

It is planned to have the January meeting a continuation of the last and arrangements are being made to have talks on metallurgical and power methods used by the Chile Copper Co.

Due to the increasing interest in engineering developments abroad, plans are being made to get into touch with men who have studied projects in Asia and Africa.

W. S. DICKSON, *Secretary.*

CHICAGO SECTION

CHARLES H. MACDOWELL, *Chairman*, GEORGE P. HULST, *Vice-chairman*,
HENRY W. NICHOLS, *Sec'y-Treas.*, Field Museum of Natural History, Chicago, Ill.
R. S. BONSIB, HORACE H. CLARK, H. T. WALSH.

The Chicago Section met Friday, November 22, for a Chuck Wagon Dinner at the Adventurers' Club. After the dinner the following officers were elected: Chairman, C. H. MacDowell; Vice-chairman, G. P. Hulst; Secretary-treasurer, H. W. Nichols; Executive Committee, A. D. Terrell, J. R. Sharp, Ray Chapman, and Prof. E. A. Holbrook. A petition was drawn up and signed by all present asking the Institute to hold its next Summer Meeting in Chicago at the time of the Chemical Exposition, and the Secretary was instructed to attend to the formalities to insure that the invitation was sent in proper form and in such a manner as to give it the best possible chances of acceptance. After the business, the motion pictures "the Way Out" prepared by the Army Medical Museum authorities to demonstrate how crippled soldiers can be educated to become self-supporting were shown.

HENRY W. NICHOLS, *Secretary-Treasurer.*

DIED IN SERVICE

Bailey, Lewis Newton, Master Engineer, Senior Grade, 4th Regiment, U. S. Engineers, Headquarters Company, died of pneumonia at Camp Merritt, N. J., on April 30, 1918.

Baird, Louis, Lieut., Royal Field Artillery, British Army, died on the battlefield in 1915.

Ballamy, John H., Capt., 103d Engineers, killed in action near Fismes, Aug. 9, 1918.

Bowles, Martin F., 2d Lieut., Co. B, 355th Infantry, killed in action, Sept. 3, 1918.

Burt, Andrew, died in active service, 1916.

Cobeldick, William Morley, Royal Engineers, died from gas poisoning on Oct. 7, 1915.

Dougall, Ralph, 4th University Co., Princess Patricia Regiment, killed in action early in the war.

Evans, Alfred Winter, Lieut.-Col., New Zealand Rifle Brigade, D. S. O., D. C. M., killed in action on Oct. 12, 1917.

Gordy, Sheppard B., died in service, Oct. 9, 1918.

Gorman, Thomas C., Lieut., Canadian Engineers, killed in France, Mar. 18, 1918.

Hague, William, 1st Lieut., Engineer Officers' Reserve Corps, died in active service, Jan. 1, 1918.

Hall, William T., Capt., Royal Flying Corps, killed in action, May 19, 1917.

Heine, Bernhardt E., Lieut., Aviation Service, died from accident at Fort Sill, Okla., Aug. 10, 1918.

Irving, John Duer, Capt., 11th Engineers, A. E. F., died July 26, 1918, while on active service in France.

Perry, Edward H., 1st Lieut., Co. D, 6th Regiment Engineers, U. S. Expeditionary Forces, France, killed in action on March 30, 1918.

Pretyman, Frank Remington, 2d Lieut., Royal Engineers, killed in action on June 17, 1916.

Reece, Fred. B., Capt., Royal Engineers, B. E. F., 232d Army Troops Co., killed in action.

Ringlund, Soren, Medical Department, Fort Logan, Colo., died suddenly in camp on July 24, 1918.

Roper, George, Jr., Lieut., Royal Flying Corps, killed in aeroplane accident in England on May 25, 1918.

Smyth, Raymond Weir, died of influenza at the Navy Yard Hospital, League Island, Philadelphia, Sept. 27, 1918.

IN MEMORIAM

LIEUTENANT MARTIN F. BOWLES

Martin F. Bowles, born Apr. 25, 1893, at Bonne Terre, Mo., and graduated from the Neodesha, Kans., High School, had finished all but one month of a four-year course in metallurgical engineering at the Missouri School of Mines, Rolla, Mo., when on May 12, 1917, he entered

LIEUTENANT MARTIN F. BOWLES.

the first Officers' Training Camp at Fort Riley, Kans. At the close of the training period, he was commissioned a Second Lieutenant and assigned to Co. B, 355th Infantry, 89th Division, and stationed at Camp Funston. He left this camp with his company on May 21, 1918, and sailed from an eastern port on June 4, arriving in England on June 15, 1918. After a short stay at a rest camp there, he proceeded to France. On August 14, he wrote that he was with Battalion Headquarters as Scout Officer, 1st Battalion, 355th Infantry, 89th Division. The last letter received from him, dated September 2, was written in his dugout and contained the following: "Here it is 2.45 A. M. Sitting in a dugout

waiting for some patrols to report back in, I am writing this by the light of two candles." He was killed in action on the night of Sept. 3, 1918. The letter of notification received from Brigadier General Thos. G. Hanson said: "It is my painful duty to communicate to you the fact of the loss of your son, Martin F. Bowles. About 11 o'clock on the night of September 3, Lieutenant Bowles, with Lieutenant Joseph B. Keckler, 355th Infantry, in command of a reconnoitering patrol of our troops, encountered the enemy. In the ensuing engagement your son received a rifle bullet through the heart. His death was instantaneous and painless. His remains were interred with full military honors on the 4th of September." He was promoted to First Lieutenant, but his commission did not reach him before his death. He was president of the Missouri Mining Association, Missouri School of Mines, for the year 1916–17.

SHEPPARD B. GORDY

Sheppard B. Gordy, born in Ansonia, Conn., in 1889, graduated from the Sheffield Scientific School in 1910 and with the degree of E. M. in 1912. For six years he was in Chile, holding the position of general mine foreman for the Braden Copper Co. He returned to this country to enlist last June. He was inducted into service on August 26, and died of pneumonia October 9, at Camp Sherman, Chillicothe, Ohio.

RAYMOND WEIR SMYTH

Raymond Weir Smyth, born Nov. 3, 1888, was the son of Herbert Weir Smyth, professor of Greek Literature at Harvard University. He

RAYMOND WEIR SMYTH.

graduated (A. B.) from Harvard in 1909 and later pursued advanced studies there in chemistry and in metallurgy. He held the position

of metallurgist for the American Steel and Wire Co. at Worcester, Mass., and also for the Steel and Tube Co. at Youngstown, Ohio. For a time he was inspector of munitions for the British Government and stationed at the Railway Steel and Spring Co. at Latrobe, Pa. For a short time, in 1917, he was Inspector of Ordnance for the U. S. Government, and the following year, having entered the U. S. Naval Reserve Force, he was ordered in a similar capacity to the Midvale Steel Co. In September, he removed to the Navy Yard, League Island, Philadelphia, to train for the obligatory minimum of six months' sea duty. There he contracted influenza, which was followed by pneumonia, from which he died, September 27, at the Navy Yard Hospital.

MEETING OF AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Human engineering was the keynote of the thirty-ninth annual meeting of the American Society of Mechanical Engineers, which was held in New York, December 3–6. This note was sounded by President Charles T. Main in his address at the opening session and was carried through by all the speakers. In his survey of the year's work, he said that more than 6000 names of engineers were furnished the Government for filling a wide variety of positions. In addition to the 1400 members in service, two members of the council of the society are in uniform in France and one, as a distinct war service, is in charge of one of the largest shipyards. After giving other ways in which the Society has helped the Government, President Main called attention to the necessity for thoroughgoing efforts to increase production and the settlement of questions involving industrial relationships.

At the following meeting, President Adams of the American Institute of Electrical Engineers called attention to the necessity of meeting labor in a progressive way, facing labor questions fairly and squarely, as the real interests of labor cannot be separated from those of the engineer.

Charles E. Knoeppel, discussing "Industrial Organization as It Affects Executives and Workers," said the problem of the cost of living might be settled in two ways: 1, there must be more producers, and 2, there must be a greater amount supplied by those now producing. The first solution is practicable, he said, if labor is allowed shorter hours, better conditions, and a remuneration that will attract workers. The second can be employed by eliminating waste, standardizing conditions, setting fair tasks, and allowing men to earn an amount that will compensate them for their skill and coöperation.

Dudley R. Kennedy of Philadelphia, employment manager of the American International Shipbuilding Corporation, said the human-engineering phase of the country's industrial development had generally been overlooked. "We hardly yet know what competition means; we will learn it within a few years. Permit me to prophesy that the executive of the next decade will be the man who best knows men. He will be an originator, a handler of men as individuals, a handler of men in the mass, a leader not a driver, a very human man. The science of human engineering is here to stay. The study of human characteristics is the most enduring, as well as the most fascinating in the world, and still the most complex."

Many of the other papers dealt with phases of the management and production problem.

Honorary membership in the Society was conferred on Charles M. Schwab and Orville Wright.

The new officers of the Society are: President, Dean Mortimer E. Cooley, Ann Arbor, Mich.; Vice-presidents, F. R. Low, New York; Henry B. Sargent, New Haven, Conn.; John A. Stevens, Lowell, Mass.; Managers, Charles L. Newcomb, Holyoke, Mass.; F. O. Wells, Greenfield, Mass.; Dean C. R. Richards, Urbana, Ill.; Treasurer, William H. Wiley, New York.

MINERS OF THE SEA*

The Marine Corps has found the Mining and Sapping Department one of the most efficient individual organizations of the Soldiers of the Sea. The men of the unit were assembled among "hard rock" miners from Montana, Idaho, and Utah; most of the detachment hail from Butte. It includes experienced gas-helmet men, blacksmiths, compressors, carpenters, timbermen, concrete and cement gun experts, diamond drill runners, civil and mining engineers, in fact, artisans of every craft in and around mines.

Experienced miners with both technical college training in mining and engineering and the practical turn of actual work as mine superintendents and foremen are used as instructors in their craft, except thirty-eight who "shoved off" with the Eleventh Regiment to actually apply their skill in Marine trenches abroad. They are the "finishers" after the trenches are dug. Covering and camouflaging the tops for protection against attacks from the air, engineering the arrangement of the trenches for protection against shell fire, establishing listening posts by projecting "Russian saps" within a few yards of the enemy's trench; sapping or tunnelling into the very lines of the Teutons, and leaving pleasant little bundles of explosives there; are just a few of the high spots touched by these wizards of the soil. They make the trenches comfortable, plastering the interiors until the underground bunk houses not only look like hotels but are just as comfortable "with all the modern conveniences." Draining is another feature which the work of the Miners and Sappers at least partially assures.

One of the striking things about the Miners and Sappers is the fact that they are much older men than the average recruit. Some actually have sons in the service. Private Denson, of Salt Lake City, has two sons in the Navy and a son and stepson in the Army. Private Heberden, of Butte, has a son in France, and so it goes throughout the personnel of the camp. Ratings are obtained for practically all of these men and Lieutenant Reed was recently commissioned from the ranks.

Each student of the Miners and Sappers' School is trained to supervise trench construction by a detail of troops. Men about to go overseas receive lessons in road construction to meet topographical adjustments so that the roadways may be concealed easily from the enemy; the relative values of trench and dugout construction; and how to arrange wire entanglements and establish telephonic communications.

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*Extract from *The Marines Magazine*, November, 1918.

TRANSACTIONS WANTED

The Institute's stock of Volumes XXXI, LI, and LII has become much reduced by sales. If members have copies of these volumes which they can spare, the price of $3 per volume will be paid for them, if in good condition. If desired, a copy of the Index for Volumes XXXVI to LV will be given for one of these volumes of the Transactions and one dollar additional. For two volumes of the Transactions, a copy of the Index will be sent and the balance will be credited to the payment of dues.

ENGINEERING SOCIETIES EMPLOYMENT BUREAU

The American Institute of Mining Engineers, the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers have established the Engineering Societies Employment Bureau under the management of their Secretaries. One of the purposes of the Bureau is to keep in touch with all engineering firms with a view to supplying them with desirable men. Plans are under way to assist in placing men who are retiring from the government service. The Bureau is not intended to be exclusively for the benefit of unemployed members of the Founder Societies; non-members who are introduced properly will be registered. Information, registration forms, etc., may be obtained from the office of the Bureau, Engineering Societies Building, 29 West 39 Street, New York, Room 903.

DINNER TO AMBROSE SWASEY

A dinner was given to Ambrose Swasey by the United Engineering Society, at the Engineers' Club, on November 14. Those present included twenty-one presidents and past presidents of the Founder Societies. Charles F. Rand, President of United Engineering Society, presided. President Robert S. Woodward, of the Carnegie Institution of Washington, and Dr. Robert W. Hunt, of Chicago, made addresses to which Mr. Swasey responded. Dr. Michael I. Pupin, Chairman of Engineering Foundation, made the closing address. The evening was marked by the high character of the addresses, inspiration for grave duties lying before the engineering profession, and by the spirit of good fellowship. Among the seventy-two persons present were the following members of the Institute: E. E. Bartlett, William N. Best, J. Parke Channing, C. R. Corning, F. G. Cottrell, J. V. Davies, J. V. N. Dorr, H. S. Drinker, Karl Eilers, H. M. Howe, A. C. Humphreys, Robert W. Hunt, Wm. B. Jackson, D. S. Jacobus, J. H. Janeway, J. E. Johnson, Jr., John Johnston, George F. Kunz, Edwin Ludlow, Philip N. Moore, Fred'k. H. Newell, Wm. H. Nichols, H. Hobart Porter, Charles F. Rand, R. M. Raymond, Jesse M. Smith, E. Gybbon Spilsbury, Bradley Stoughton, Joseph Struthers, Benj. B. Thayer, Wm. H. Wiley, S. T. Wellman.

ORGANIZATION OF RESEARCH*

It is well to bring before you again the chief purpose of the National Research Council and of this its Division of Engineering, to stimulate

* Remarks of Dr. Henry M. Howe, Chairman, at the Meeting of the Advisory Committee of the Engineering Division of the National Research Council, held in New York City on Nov. 15, 1918.

others to make researches rather than to make them ourselves, because a given amount of our energy spent in inciting others will accomplish far more than if applied in executing them ourselves. This is because there are scattered through the numberless governmental, educational, and industrial laboratories of the country a very great number of investigators not only capable of being stimulated, but willing to aid in coöperative broadly planned research rather than to follow the haphazard methods of the past.

Taken collectively, these laboratories and their personnel can produce an annual crop of knowledge the value of which is of the order rather of billions than of millions of dollars. I invite you to regard this potential product as a crop, to be planned, fertilized, harvested, and distributed with the same order of statesmanship, the same breadth of view, with which we treat any other great human product or achievement, whether agricultural, industrial, or transportational.

The displacement of the stage coach by an advanced and centralized system of transportation was neither more needed nor more inevitable than the replacement of our past method of haphazard research, with its misguidance, its lack of interpretation, of clarification and of diffusion, its desultoriness, its duplication, by an advanced, guided, and collaborative arrangement which shall plan vast systems of research broadly, shall execute them methodically and economically, and shall so clarify and distribute their results that they shall serve mankind most quickly and most efficiently. As it is to some to farm, to others to mill, to others to transport, to others to distribute, and to still others to bake, so does God give to some the vision to plan, to others the skill to execute, to others the analytical power to interpret, and to others clarification, replacing rawness of crude truth with such attractiveness, such zest leading to eager assimilation, as the *cordon bleu* gives the miller's product.

In the haphazard past each investigator was his own planner, manipulator, interpreter, and clarifier. However efficiently he did that fraction of this complex work which God traced for him, he worked with relative inefficiency at the three others.

The evolution of research should be directed toward this end, of giving to each investigator the specific part of this team work for which he is fitted by Nature. But quite as the evolution of our transportation system has taken many decades and has occurred in large part through trial and error, so is it likely to be with the evolution of research.

The National Research Council aims to devise a mechanism and procedure which shall at least lead to some important progress in this direction.

It is well to face squarely the difficulties, and especially the psychological ones.

Our truly democratic aims must show their democraticness convincingly. We must make plain our desire to stimulate investigators according to their inherent fitness, their fertility and powers of production, rather than according to the prestige or importance of the institutions with which they are connected. We must convince not only the engineering profession but also the various coöperating investigators that we aim to distribute public recognition among them equitably. We shall have the delicate task of selecting officers with the skill needed for assigning the different parts of the team work of research accurately. Success clearly depends to an unusual degree on putting the right men in charge.

The catholicity of our course is shown by our having already caused one or more researches, of greater or less importance, to be undertaken in each of 35 different laboratories in 11 different states. We have drawn on not only some of the great industrial, educational, and governmental laboratories, but on many of very moderate size, and indeed on some little known private laboratories.

Here we may ask whether our national engineering societies might not with advantage give more attention than at present to the promotion of research, and whether the National Research Council might not coöperate very closely with them and with the Engineering Foundation in this work. This coöperation might assume any one of several different forms. For instance, the Council could act as their department of research, as it does now toward the Council of National Defense and as it has toward the Signal Corps. Or it might act in any advisory way, or with any intermediate degree of responsibility that might be decided on. A relation which would make it clear that the weight and authority of these bodies supported the policy and acts of our Engineering Division should lessen the psychological difficulties to which I have referred. We all know that an author is pained far less if the rejection of a professional paper is by a committee than if it is by an individual officer. On this same principle, the increase in our weight, responsibility, and authority which such an association with these great engineering bodies would create, beside increasing the attractiveness of our invitations to coöperate in research, and make our decisions, selections, and appointments juster and wiser, would make their wisdom and justice more convincingly evident.

The end of the war, the victory of the world's train-load of passengers over the anachronous and brutal robbers who have tried to hold it up at pistol's point, leaves us all unsettled. We have to adjust ourselves to an order which must needs differ materially from the old. This period of adjustment, this general unsettling of mankind, lends itself to advances of all kinds. The frictional resistance to change which it offers is of the low friction of motion as distinguished from the high friction of repose. Now is the time to plan for the new order of research.

The reconstruction of our own conditions and of those of Europe and Africa will call for as high an order of patriotism as the war has demanded, for while the need of wisdom and energy will be as great, the emotional attraction of war will be lacking. Our devotion to this work is called for not only by humanity but by enlightened interest. Only as Europe is rich and prosperous can she buy of us. Only as a thoroughly penalized Germany is enabled to create wealth can she pay her debt. That a debtor is an asset is as true of nations as of individuals. Of course we must care first for allies, then for the truly neutral states, and then for the nominally neutral ones. After this and after doing all we can to hasten the development of the African colonies, with due care that they shall go only to those powers which have proved their fitness for the uplifting of backward peoples, it will be to our interest to enable even Germany to renew her industries, though, of course, our help must be guarded. Here, as ever, the dictates of humanity and of enlightened self-interest are alike.

NOTE.—The remainder of the address was devoted to describing the work of the seven committees now at work and to outlining that of fourteen new committees now proposed.

SUGGESTIONS FOR PREPARING MANUSCRIPTS

Have your name and address on the first page of your manuscript. Typewritten manuscript is preferred, but is not essential. If you have the manuscript typewritten, have it double spaced and written on one side of the page only; send two copies to us if convenient; only one copy of the illustrations is desired. In typewritten manuscript, formulas are better inserted by hand. Keep a copy of your manuscript in case of loss in the mail.

ILLUSTRATIONS.—Photographs reproduce best when printed on glossy paper. Solio is one of the best varieties. A good print is preferable to a negative. Blueprints, drawings, or pen or pencil sketches can be used for line engravings, but care should be exercised to make them legible and clear, especially in the case of blueprints. Tracings or photographs of drawings are preferable to blueprints. Rough sketches can be used, if necessary. Photographs should be sent flat, not rolled. Do not put reference letters or other marks on photographs; if such letters or marks are necessary, fasten a piece of tracing paper to the top edge, trace a rough outline of the picture upon it and then place all letters, etc. on the tracing paper in the exact position you wish them to appear.

Restrict the number of micrographs as much as possible on account of the considerable expense involved. Standard magnifications for nonferrous metals and alloys are recommended as follows: 10, 25, 50, 75, 100, 150, 250, 500, 750, 1000, 1500. Micrographs should be trimmed to $2\frac{1}{4} \times 2\frac{1}{4}$ in. (six micrographs to a plate), or, if larger, up to $3\frac{1}{2} \times 4$ in. (two to a plate). The smaller size should be adopted if consistent with adequate representation of the subject. With each micrograph should be attached an explanatory title, together with the actual magnification, etching medium, treatment, etc., indicating what the author intends to show.

Diagrams in which there is little or no detail should be drawn in the size that they are desired to occupy within the typed area of the page ($4\frac{1}{2} \times 7\frac{1}{4}$ in.). Large-scale drawings will be suitably reduced. The lettering on such drawings should be in form for reproduction without additional tracing, etc.

Where illustrations are very numerous, indicate those that may be omitted with least loss if a reduction in number be desired.

CONCISENESS.—Delay in publication, lack of attention by readers, and subsequent trouble to authors is often caused by diffuseness.

REFERENCES.—Confine your paper particularly to new material unless it is intended to be a review or retrospect of a subject. Reports of researches may profitably be introduced by a description of the prior art. Footnotes in manuscripts should be inclosed between two horizontal lines immediately following the reference mark. If a book, give author, title, volume, page, year and city of publication, and publisher's name. If a periodical, give title, volume, number, page, and date, as here shown, if available: *Engng. & Min. Jnl.* (Apr. 21, 1900) **69**, 469.

ABBREVIATIONS.—Always use figures for weights, measures, percentage, degrees of temperature, sums of money, and for articles definitely numbered, such as No. 2 pig iron, Furnace No. 3, Test 2 of Series VI, etc. In other cases, spell numbers less than 10 and use figures for 10 and larger numbers.

The following examples show also some abbreviations to be used:

2 lb.	(not lbs. or pounds)
7 ft. 6 in.	(not 7′ 6″, or 7 feet 6 inches)
9 by 12 ft.	(not 9 × 12)
18 per cent.	(not 18%)
43° F.	(not degrees, or Fahr.)

If no definite quantity is mentioned, do not abbreviate pounds, feet, etc. Example: Several feet distant (not several ft. distant).

In decimal numbers having no units, place a cipher before the decimal point, as 0.28 gm. (not .28).

A STUDY OF ENGINEERING EDUCATION

This study of engineering education arose out of the action of a joint committee on engineering education, representing the principal engineering societies. The committee had gathered so much material that it decided the work could best be carried out by some one trained in applied science, who would devote his entire attention to the study. The Carnegie Foundation therefore asked Prof. Charles R. Mann, of the University of Chicago, to undertake the work. After making a thorough study Prof. Mann has made a most comprehensive report. In it he says: The engineering schools of the United States began their work upon a definite teaching plan and one that had at least pedagogic consistency. But during the past half century the course of study has been overlaid with many special studies intended to enable the student to deal with the constantly growing applications of science to the industries. As a result, the load upon the student has become so heavy that there is a feeling that the students fail to gain a satisfactory grounding in the fundamental sciences and do not fulfil the expectations of engineers and manufacturers in dealing with the practical problems with which they are confronted on leaving school.

At present 60 per cent. of those who enter the schools fail to graduate, still many of them persist in engineering and make a success of it. It is evident, therefore, that the present systems of admission are not satisfactory. If a group of schools will take up the careful study of their entrance systems and experiment with objective tests and records of the students' youthful interests and achievements, the percentage of elimination can be reduced to at least a fourth of its present size, with an enormous saving of time, energy, and money for both student and school.

The number of required credit hours per week should be less than eighteen, preferably sixteen. The few experiments that have been made indicate that college students do their best work when not more than five subjects are studied at a given time.

A third essential is adequate provision in the first two years for "orientation," contact with real engineering projects, and practical experiences. Orientation lectures to freshmen meet this requirement to a certain extent; practical work in surveying parallel with trigonometry during the first term of freshman year is perhaps more effective; but the coöperative system of Cincinnati University is the most complete and thoroughgoing solution of this problem yet presented. One of the common complaints of employers is that college graduates have serious

difficulty in applying theory to practice. Hence there is need for interrelation between the concrete and the abstract throughout the entire college course. Universal experience indicates that the most effective method of learning is by doing; so if engineering depends ultimately on power to interrelate theory and practice and costs, a training that requires the student frequently to interrelate these three fundamental factors is likely to yield a better product than is secured from a training that largely ignores their interdependence.

Professional criticisms of the schools indicate that the humanistic study offer the greatest opportunity for effective changes in current practice, because lack of good English, of business sense, and of understanding of men are most frequently mentioned by practising engineers as points of weakness in the graduates of the schools. The criticisms point out two types of weakness, namely, lack of technical facility in expression, in business, and in handling men; and lack of appreciation of and interest in literature, economics, and social philosophy. The difficulty in the present practice evidently lies in the exclusion from the technical work of all consideration of the questions of human values and costs, and the isolation of the humanistic studies from all technical interest.

Three-fourths of the 1500 practising engineers questioned on the subject agreed that they had never found foreign languages essential to their professional careers, and one-half of them thought that they should not be required. In addition, there is a growing conviction among the schools that for students of engineering the time now spent in college on foreign languages may be much more profitably spent in other ways.

The first step toward successful specialization is intelligent sorting of the students, so that each is led as definitely as possible into that type of work for which he is fitted temperamentally. It should be possible when the students finish the common core of the engineering curriculum to divide them into five or six groups. For each one of these groups, a curriculum should be framed by a competent committee on the same plan as that used for the common core. There is, however, an urgent need that a number of the schools add to these semi-specialized groups one in production engineering. The seriousness of this need has been emphasized by war conditions. Until recently most schools have specialized in design, with the result that at present fully 95 per cent. of the production managers in manufacturing plants are not college, but shop-trained, men.

A number of representative engineers, when questioned concerning the factors that are most powerful in determining success in engineering work and most effective in building up the engineering profession, indicated that personal qualities such as common sense, integrity, resourcefulness, initiative, tact, thoroughness, accuracy, efficiency, and understanding of men are universally recognized as being no less necessary to a professional engineer than are technical knowledge and skill. A circular letter stating this result was sent to the 30,000 members of the four large engineering societies, and each member was asked to number six groups of qualities headed respectively Character, Judgment, Efficiency, Understanding of Men, Knowledge, and Technique, in the order of importance which he gave them in judging the reasons for engineering success and in sizing up young men for employment or for promotion. More than 7000 engineers replied to this request, and 94.5 per cent. of these placed

Character at the head of the list, while Technique was placed at the bottom by an equally decisive majority. Therefore the schools that intend to train engineers cannot afford to neglect wholly the personalities of the students. While it is obvious that personal traits like integrity, initiative, and common sense cannot be taught didactically, like the rule of three, the growth of these essential characteristics in students may be fostered and encouraged or inhibited or discouraged by the manner in which the school is organized and the subject-matter presented.

STANDARDIZATION OF TERMS USED IN HYDRO-METALLURGICAL OPERATIONS*

Percolation infers the passage of a liquid through the interstices of any material or materials permitting it. Leaching is the process of extracting soluble matter by percolation. Lixiviation is analogous to leaching. Percolation and leaching may occur simultaneously. A filter may be used either to strain suspended or finely divided matter from a liquid, when it is known as a clarifier, or to separate a liquid from a solid. Clarification usually infers the addition of some settling or flocculating agent which permits the decantation of the clear supernatant liquor. The simple separation of solid from liquid, such as occurs when a thickened flotation concentrate is filtered, is usually termed dewatering. The word filtration is used more to cover the complex process of separating, as far as possible, solid from liquid by vacuum or pressure, removing the residual solution by wash, and at the same time leaching any recrystallized, absorbed, or undissolved matter by percolation with the solvent.

The final product of metallurgical treatment should be reported as a recovery when the yield is refined metal. When the metallurgical operations are incomplete and a concentrated but not refined product is obtained, the metal content should be reported as an extraction.

NEWS FROM MEMBERS IN SERVICE

Major William R. Grunow, in a brief account of his military services, says: "I take pleasure in informing you that since my return from France I have been stationed at Camp A. A. Humphreys, Va., and am now on duty as a Senior Instructor at the Engineer Officers' Training School. While in France, I served as a company commander in the 305th Engineers and was later ordered to return to the United States for assignment to new troops. Upon arrival in the United States, I received my majority."

P. F. Rodegerdts gives us the following account of his military service: "I enlisted in the Naval Reserve Flying Corps in San Francisco on Feb. 12, 1918. On February 16, I was ordered to Cambridge, Mass., where I was enrolled for the course in technical aircraft construction given at Massachusetts Institute of Technology. After successfully completing the course of instruction, I spent six weeks in practical construction of seaplanes at the Curtiss aeroplane factory in Buffalo. Following this, I was assigned to active service at Akron, Ohio, on June 22, 1918. At the same time I received my commission of ensign U. S. N. R. F. Unfortunately, I have been kept at Akron and although I have made

* By A. W. Allen, *Engng. & Min. Jnl.*, Oct. 26, and Dec. 7, 1918.

repeated requests for foreign service, they have been unsuccessful. My duties here have been specifications and experimental design for lighter-than-air craft being built by the Goodyear Tire & Rubber Co. The work has been interesting, with plenty of opportunity to fly, but it is rather discouraging to feel that one has had to "fight the war in Akron" instead of in France. I expect to stay in the service until about June, 1919, when the present program of construction will have been completed."

Major B. W. Vallat of the 6th engineers writes us the following particularly interesting letter. "Just coming out of the line for a rest after a hard bit of service and relaxing *nerves*, I feel that I might unload a few statements upon you which will give you an idea of what the engineers are doing over here, only from my own experience, of course. First let me say that the mining engineer has made good in front-line service in this war—and without any special training in the military service—simply because he knows how to handle a situation that suddenly develops and "wasn't in the book." He handles it a little better than the other fellow who has not had the misfortune to have been a mining engineer.

"I know what I am saying because I had the honor of organizing and going into service with a battalion of mining engineers from the Lake Superior and western district, and even South Africa and South America. This battalion was officered entirely by the alumni of the Michigan College of Mines, with many of the graduates in the ranks, and was for the most part made up of fine husky young fellows who were miners, timbermen, carpenters, riggers, blacksmiths, etc. in and about the mines. Many of the officers are members of the Institute. This battalion became the 1st Battalion of the 107th engineers attached to the 32d Division, built Camp McArthur at Waco, Tex., and sailed for France on Jan. 29, 1918.

"The regiment was put to work as soon as it arrived in France, constructing barracks and hospitals in the "advanced zone," until June, 1918, when we joined the 32d Division on the Alsace front overlooking Mulhouse. My battalion was attached to the 40th French Army Corps, for whom we constructed the main line of resistance against counter-attack. In this work we did everything from digging trenches, putting in defensive wiring, dug-outs, camouflage, all under fire, to blowing up enemy wire entanglements for our infantry attacks. This work our miners and mining engineers fairly "ate alive" without having had much previous training in these particular operations. Our work here called forth the admiration and praises of the French Corps officers, both engineer and line.

"Our next big job started July 25, when we were rushed over to Chateau Thierry, crossed the Marne, and took up our sector in the big drive to the Vesle river. Our problem here was a big one. It consisted first in getting our army forward with all possible speed over impassable roads, building emergency bridges to replace those destroyed by the enemy, preparing pontoons for crossing the Vesle river, besides many side issues of our own, such as carrying in wounded and carrying out food to isolated groups of infantry in the front line who could not be reached in the regular way. Again our mining engineers showed their adaptability and resourcefulness and we "got the army forward," whether it was according to the approved methods of our regular army engineers or not. We got results good enough to draw forth the commendation of the commanding general of the division. You will remember the rapid ad-

vance here between July 28 and August 6, covering record distances. Those were the times we didn't sleep for days and our men worked until they dropped from wounds or exhaustion. The experiences met with would make a story in itself of interest to our engineers at home, and if we ever get back there we will be glad to tell you "everything we know."

"The A. E. F. has no regard for congenial families, and started to break us up after this. On September 1, I was assigned as C. O. 1st Battalion 6th Engineers, which is considered the first in the regular army and has a wonderful record over here for its past work. It was this regiment that held the British line at Amiens last March until relieved. The 6th is part of the 3d Division and 3d Army Corps. It is a wonderful organization and I am proud to be part of it.

"If I thought I had seen hard service with the 107th it was because I didn't know what was before us. On September 15, we started a series of marches in rain and mud, such as only France can produce, and after mobilizing with the 3d Division prepared for a "big show." On September 26, we started in the big drive of the First American Army west of Verdun. We marched in mud and rain again until we got to what were once roads through what had just been "no man's land." Here we found ourselves corps engineer troops, again following up a big drive, and it was up to us to get the army forward. The rains continued. We lived in shell holes (when we sat down for a rest), fought the roads night and day, and handled all traffic through. The last statement means much more than I can explain now—it might express the situation better by saying "we *man-handled* traffic through." This continued until October 5, when we were called into the line as infantry reserves. This means that we just moved around back of the line under a harrassing and destructive fire from the enemy, which was most trying. On October 20, we were called upon to make an attack on the first important army objective (Claire Chéne Forest), hold it, and fortify it. This we did in the face of serious difficulties and held it for six days longer before being relieved. Our men displayed a wonderful spirit under most trying conditions, all of which will come out later.

"I trust this will give you some idea of what our engineers are doing over here. We all hope that we have seen the last of the heavy work and that we may soon be home to tell you more about it."

ADDITIONAL LIST OF MEMBERS OF THE INSTITUTE IN MILITARY SERVICE

(The following list contains the names of those members of the Institute of whose connection with military service we have only recently become acquainted.)

ADAIR, ARTHUR C., Corporal, 4th Co., 1st Tr. Bn., 154th D. B., Camp Meade, Md.

BATCHELOR, STILLMAN, 1st Lieut., Co. 6, E. O. T. S., Camp Humphreys, Va.

BATES, BENNETT R., 1st Lieut., Engineers, Co. 3, E. O. T. S., Camp Humphreys, Va.

BJORGE, GUY N., Co. 3, E. O. T. S., Camp Humphreys, Va.

BOAS, ROSS H., U. S. A.

BRADLEY, D. H., JR., Capt., 408th Engineers, Camp Cody, N. M.

BRINTON, OWEN F., Capt., Engineers, U. S. A.

BROWN, HAROLD C., 2d Lieut., A. S. A. P.

BURDETTE, R. S., Capt., Ordnance Dept., U. S. A.

COLBURN, C. LORIMER, Capt., 140th Engineers, Camp Shelby, Miss.

CORBETT, CLIFTON S., 2d Lieut., C. A., O. R. C.

DUNCAN, DAN MCLEAN, 2d Lieut., 312th Engineers, A. E. F.

FLEMING, J. R., 1st Lieut., A. S. A., U. S. Army School of Military Aeronautics, University of Illinois, Urbana, Ill.

GALBRAITH, CHARLES S., Sapper No. 52526, Australian Engineers' Depot, Brightlingsea, Essex, England.

GOLDSMITH, OSHER, Candidate, 22d Training Battery, F. A. C. O. T. S., Camp Zachary Taylor, Ky.

HAMMITT, E. P., Lieut., 319th Engrs., American E. F., France.

HILL, JOSEPH H., Co. D, 209th Engineers, Camp Sheridan, Ala.

IDDINGS, ARTHUR, Cadet, Air Service, Hanover, Ind.

INGERSOLL, GUY E., U. S. Army.

KISHMAN, MAURICE W., 1st Lieut., E. O. T. S., Camp Humphreys, Va.

LASIER, FREDERICK G., Capt., Engineers, Room 4–336 Office, Chief of Engineers, War Dept., Washington, D. C.

LITTLE, JAMES M., 1st Lieut., Engineers, U. S. A.

LONGYEAR, J. M., JR., 2d Lieut., Coast Artillery, O. R. C.

LYNCH, WILLIAM W., 27th Engineers, American E. F., Care Postmaster, New York.

MCHARDY, R. H., Candidate, Co. 3, Coast Artillery Training School, Ft. Monroe, Va.

MERRITT, FLOYD C., U. S. A., Camp Humphreys, Va.

NEUSTAEDTER, HAROLD A., Erie Proving Grounds, Ohio.

OLINGER, ROBERT W., 35th Co., Central Machine Gun O. T. S., Camp Hancock, Ga.

OLIVEROS, REGINALD P., U. S. Army.

PEHRSON, ELMER W., Co. 6, E. O. T. S., Camp Humphreys, Va.

REED, CARL S., Major, Ordnance Dept., U. S. A., 1107 Broadway, New York City.

RICHELSEN, WALTER A., 1st Lieut., 428th Engineers, U. S. A., Camp Humphreys, Va.

ROBERTS, THOMAS S., 1st Lieut., Co. 3, Camp Humphreys, Va.

SANFORD, CHARD O., 1st Lieut., 403d Engineers, Port Douglass, Utah.

SCHMIDT, WILLIAM C., JR., Co. 6, E. O. T. S., Camp Humphreys, Va. (Discharged Nov. 27, 1918.)

SEGALL, JULIUS, 4th Co., U. S. A., S. A. P., Kodak Park, Rochester, N. Y.

SHEARER, HAROLD K., Field Artillery Officers' Training School, Camp Zachary Taylor, Ky.

SPRUANCE, W. C., JR., Col., U. S. A., Ordnance Dept., Washington, D. C.

SULTZER, H. D., 1st Lieut., 417th Engineers, Camp Humphreys, Va.

THOMPSON, WARREN D., Co. 3, E. O. T. S., Camp Humphreys, Va.

TROUNCE, HARRY D., Capt., Engineers, U. S. A., 606th Engineers, Camp Humphreys, Va.

VOGEL, HERMAN H., Medical Replacement Unit No. 35, Overseas Casuals, Camp Merritt, N. J.

WESTERVELT, E. W., Lieut., E. O. T. S., Camp Humphreys, Va.

WILLISTON, GEORGE F., Artillery O. T. S., 1st Co., Ft. MacArthur, Calif.

WOODWORTH, GUY T., 361st Ambulance Co., American E. F., France.

PERSONAL

The following is an incomplete list of members and guests who called at Institute headquarters during the period Nov. 10, 1918 to Dec. 10, 1918.

Arthur C. Adair, Camp Meade, Md.
Arthur K. Adams, Camp Humphreys, Va.
Toner Antisell, Chevy Chase, Md.
V. W. Aubel, New Castle, Pa.
A. C. Black, El Paso, Tex.
O. F. Brinton, Baxter Spgs., Kans.
C. S. Corbett, Minneapolis, Minn.
W. M. Corse, Mansfield, Ohio.
G. C. Crossley, Toms River, N. J.
H. S. Emlaw, Grand Haven, Mich.
Rudolph Emmel, Boston, Mass.
S. G. Garrett, U. S. N. R. F.
Lt. Francis Geib, Denver, Colo.
Wm. E. Hubbard, Wichita Falls, Tex.
Arthur Iddings, Wichita Falls, Tex.
Zay Jeffries, Cleveland, Ohio.
S. J. Kidder, Mogollon, N. M.
Lt.-Col. W. H. Lanagan (Engrs.).
Major W. F. Lewis (Engrs.).
O. M. Lewyn,
A. McClintock, DeKalb Junc., N. Y.
Major Donald G. Miller, N. M.
L. S. Mitchell, Montreal, Canada.
T. E. Mitchell, San Francisco, Cal.
H. Mortimer-Lamb, Montreal, Canada.
Edmund Newton,
Paul T. Norton, Jr., Columbus, Ohio.
Elmer W. Pehrson, San José, Cal.
Joseph E. Pogue, Washington, D. C.
T. C. Roberts, E. Orange, N. J.
D. R. Semmes, Richmond, Va.
H. L. Slosson, Jr., San Francisco, Cal.
W. H. Staver,
A. L. Sweetser, Boston, Mass.
Lt. H. B. Taylor, Kansas City, Mo.
Kirby Thomas, New York.
Benj. F. Tibby, Salt Lake City, U.
J. L. Towne, Whitepine, Colo.
Chas. W. Tubby, St. Paul, Minn.
A. G. Waite, Brookline, Mass.
Timothy D. Walsh, Denver, Colo.
Thomas Warner, Phoenix, Ariz.
J. P. B. Webster, London, England.
E. W. Westervelt, Los Angeles, Cal.

C. E. LeN. Arnold, formerly with the Inspiration Cons. Copper Co. at Inspiration, Ariz., has accepted a position with the Consolidated Arizona Smelting Co. at Mayer, Ariz.

U. H. Berthier has been transferred from the Higueras Unit of the Compania de Minerales y Metales, S. A., to the lead and copper smelter of the Compania Metalurgica de Torreon, S. A., at Torreon, in the capacity of assistant superintendent.

Harry Boyle is chief inspector for the United States Fuel Administration in Seattle, Wash.

Frederick J. Brulé is in the construction department of the Braden Copper Co., 120 Broadway, New York.

Frank D. Carney has removed from Bethlehem, Pa., to 40 Wall St., New York City; he is with Carney & Lindemuth, consulting engineers and metallurgists.

T. C. Chen has accepted the position of blast-furnace engineer with the Yangste Engineering Works, Seven Mile Creek, near Hankow, China.

Charles Y. Clayton, recently with the Department of the Interior, Bureau of Mines, Pittsburgh, Pa., after Jan. 1, 1919, will be connected with the Missouri School of Mines, Department of Metallurgy and Ore Dressing.

H. A. DeWitt has changed his position from mining engineer with the Chiksan Mining Co., of Korea, to that of mining engineer with the Colorado Mining Co., of Arroyo, Masbate, P. I.

Clarence T. Emrich resigned his position as chief chemist with the Old Dominion Co. to accept the position of assistant superintendent with the International Smelting Co. at Miami, Ariz.

M. R. Evans, formerly senior inspector with the Associated Companies, has resigned to accept the position of safety engineer for M. A. Hanna & Co., of Cleveland, O., with headquarters at Wilkes-Barre, Pa.

Walter V. Fox has assumed the management of the Ward Mining and Milling Co., operating a 350-ton per shift zinc mine and mill at Lincolnville, Okla., and also a gold property in Gilpin Co., north of Idaho Springs, Colo.; his new address is P. O. Box 202, Quapaw, Okla.

Chester A. Fulton is now superintendent of the Carlota mines, Cumanayagua, Provincia Santa Clara, Cuba.

P. S. Haury, late of Alta Loma, Calif., is now with the Silver State Mines Co. at Lower Rochester, Nev.

Willis Lawrence has accepted a position as manager of the Estaca mines of the Mexican Candelaris Co., S. A. Care Escobosa, Burns y Cia., San Ignacio, Sinaloa, Mexico; he was recently manager of the Oat Hill quicksilver mines.

E. T. Lednum has changed his position to that of manager with the E. I. DuPont de Nemours Co., Ideal Bldg., Denver, Colo.

Lewis B. Lindemuth, of the firm of Carney & Lindemuth, formerly at Bethlehem, Pa., now has offices at 40 Wall St., New York City.

H. T. Marshall is with the Nevada Consolidated Copper Co. at the Steam Shovel mine, Ruth, Nev., where he holds the position of chief engineer.

Phillip Maverick is with the Greene Cananea Copper Co. at Cananea, Son., Mexico, in the capacity of testing engineer.

T. Poole Maynard, Ph. D., geological and industrial engineering, Atlanta, Ga., has been made southern representative of the Research Corporation of New York.

Whitney P. Mee is chief chemist with the American Smelting & Refining Co. at the Matehuala plant, San Luis Potosi, Mexico.

David Morgan, formerly superintendent of the United Verde Extension Mining Co., has accepted the position of manager with the Verde Combination Copper Co. at Jerome, Ariz.

John W. Moule is leaving the Great Cobar Co. to become assistant manager for the Burma Corporation Limited, Namtu, Burma.

Robert Musgrave, mining engineer, has accepted a position with the Moctezuma Copper Co. at Nacozari, Sonora, Mexico.

Charles A. Randall has been appointed manager of the Dome Lake Mining and Milling Co., Ltd., South Porcupine, Ontario, Canada, in place of A. H. Brown, resigned.

Brent N. Rickard, metallurgist, has accepted a position with the American Smelting & Refining Co. at the plant in Murray, Utah.

Charles H. Schmalz has accepted the position of superintendent with the Hanna Engineering Works, 1765 Elston Avenue, Chicago, Ill.

J. T. Shimmin is at present with the Arizona-Hercules Mining Co. at Belgravia, Pinal Co., Ariz., as superintendent of the plant.

Arthur L. Sweetser, mining engineer, has accepted a position on the editorial staff of the *Engineering & Mining Journal,* 10th Ave. & 36th St., New York, N. Y.

Percy C. Thomas has resigned his position as manager of mines with the New River Co. and has accepted a position as general manager with the East Gulf Coal Co., East Gulf, Raleigh Co., West Va.

Marvin J. Udy has accepted the position of chief chemist with the Haynes Stellite Co., of Kokomo, Ind.

S. Power Warren is at present employed on the metallurgical staff of the Utah Copper Co. at Salt Lake City, Utah.

Henry S. Winans, of Denver, Colo., has resigned his position with the W. S. Tyler Co., of Cleveland, Ohio and is now representing, from Denver to the Pacific Coast, Chalmers & Williams, of Chicago Heights, Ill.

Oba Wiser has resigned his position as metallurgical engineer for Chino Copper Co., Hurley, N. M., to assume the active management of the Republic Mining and Milling Co., Hanover, N. M.

ENGINEERS AVAILABLE

(Under this heading will be published notes sent to the Secretary of the Institute by members or other persons introduced by members.)

No. 504.—Member, technical graduate, draft exempt, who has been employed as research chemist in cyanidation and flotation for past 5 years, desires position with large company as metallurgist or assistant mill superintendent. Especially experienced in flotation of gold and silver ores, but am also familiar with flotation of lead-zinc ores. Foreign service not desired. Will be at liberty after Dec. 1, 1918.

No. 505.—Member, graduate mining engineer, with 8 years' practical experience, including experience as superintendent. Desires position as engineer, foreman or superintendent of mine.

No. 509.—Petroleum geologist and engineer, member, now engaged in consulting work, with five years' experience in Mid-Continent and Eastern fields, desires position with responsible concern either in South or South American countries.

No. 510.— Chemical engineer, member, technical graduate, at present officer in Chemical Warfare Service of the United States Army, desires position in the East. Several years' experience in design, construction, and operation of chemical and metallurgical plants. Minimum salary, $200. Available Jan. 1, 1919.

No. 511.—Mining engineer, 32 years old, single, desires position. Speaks Spanish and French. Recently manager of large copper mines. Experience in steam shovel and underground mining.

No. 512.—Mining engineer, technical graduate, member, 32 years old, single, 10 years' experience in United States, Mexico and Central America in mining, prospecting, milling, chemical research and business experience. Speaks Spanish. Open for engagement as superintendent or assistant. Can give references as to ability and integrity.

No. 513.—Steel plant engineer. Member, technical graduate, married, age 28, four years' experience in efficiency, drafting and operating in steel plants. Executive ability. Desires a change of position. Will consider a foreign proposition.

No. 514.—Member, age 27, geologist and chemist, with experience in the analysis and production of the ferro-alloys, particularly ferro-tungsten and ferro-molybdenum and of the ores of the rare metals, open for engagement. At present engaged in research work in the Chemical Warfare Service.

No. 515.—Member, age 33. Graduate mining engineer with 10 years' experience in copper, iron and gold; also open-pit mining. At present Major of Engineers, U. S. Army, but expect to be able to obtain discharge soon.

No. 516.—Metallurgical and chemical engineer, married, age 34,

degree Ch. E. Eleven years' experience in the technical direction of chemical, physical, and metallurgical laboratories, and the supervision of the heat treatment of carbon and alloy steels. Available now.

No. 517.—Engineer or superintendent. Member, technical graduate, 41 years old. Ten years in Mexican mines, speaks Spanish, 8 years in this country. Experience in office account installing and keeping, surface layout, and underground work both in development and in producing mines.

No. 518.—Member, single, age 35 years, 7 years' experience in metal mining, all capacities, in West, Chile and British Columbia. Resigned position of supt. small gold mine in British Columbia to accept commission in Engineers, U. S. A. Now open for immediate engagement as metal-mine superintendent or assistant in U. S., Canada or northern Mexico, or on examination work. Energetic, resourceful, and can furnish best of references.

No. 519.—Position wanted as examining engineer by member having technical training and 8 years' experience in examinations, assay office, cyanide plant and operation of mine. No objection to foreign countries.

No. 520.—Member, age 35, married. Experience in gold dredging, and placer, clay, and lode mining in the United States and Mexico. Two and half years with present employers as general superintendent of mines and milling department. Available on 30 days' notice.

No. 521.—Member, graduate engineer, over 20 years' experience in connection with large coal operations, including positions as general superintendent in different parts of country, desires position as general superintendent with large operating company or will take an interest with the management of a smaller operation. Good references if desired.

No. 522.—For staff position, or manager. A technically trained graduate, E. M., of 18 years' experience chiefly devoted to the mining and metallurgy of gold and silver and in part with copper and manganese, terminating his third engagement by the present firm as engineer and metallurgist, will be available December 1, for service in United States, Canada, Central America or the Rand. Reference, qualifications and details may be consulted at the office of the Institute.

No. 523.—Member, age 33, single, graduate engineer. Experience as assayer, surveyor, mine accountant. Held positions as foreman and superintendent of mines, and engineer in consulting capacity. At present an ensign in the U. S. Navy, but open for engagement in the near future.

No. 524.—Superintendent or mining engineer, technical education. Ten years in mining and construction work in Southwest as engineer and superintendent of copper and lead-silver properties. Free after January 1.

No. 525.—Member, technical graduate, married, age 34. Seven and one-half years' experience in mining, timbering, and mine sampling. Prefer position assisting mining engineer. At present Captain in U. S. Army, commanding a battalion of the 19th U. S. Infantry, but open for engagement in near future.

No. 526.—At liberty about Mar. 1, 1919. Returning from France, a Captain of Engineers. Member A. I. M. E., A. I. E. E., 35 years old, technical education. Last six years of civil life as electrical engineer,

master mechanic and superintendent of construction with large mining company. Salary expected, $3600 per year.

No. 527.—Artillery officer at present in France, graduate mining and metallurgical engineer with 8 years' practical experience in mining, milling including flotation, and smelting, desires position with developing or operating company upon release from Army. Will go anywhere.

POSITIONS VACANT

Wanted.—Engineer for copper-leaching plant, designing building and operations. No. 361.

Wanted.—Competent, designing-engineer draftsman, experienced in mill design, construction and operation. Also in cement works engineering, ore-dressing or concentrating plants. Should be able to design and make working drawings of machinery. Salary $3000. No. 362.

Assistant Manager.—By large mining and cyanide milling company, located in Northern Mexico. Applicant must be mining engineer with executive ability; must speak Spanish; have good practical knowledge of principles of mining and cyanidation silver sulfide ores; must be capable of handling large organization during absence of manager. Only first-class, competent man below middle age need apply. Copies of references and full information covering experience required. State minimum salary expected. No. 363.

FORTHCOMING MEETINGS OF SOCIETIES

Organization	Place	Date
		1919
International Mining Convention (Auspices, Vancouver Chamber of Mines)	Vancouver, B. C.	Jan. 8–10
American Institute of Consulting Engineers, Inc.	New York, N. Y.	Jan. 13
American Society of Civil Engineers	**New York, N. Y.**	**Jan. 15–16**
Institute of Chemical Engineers	Chicago, Ill.	Jan. 15–18
American Wood Preservers Association	**St. Louis, Mo.**	**Jan. 28–30**
American Society of Heating and Ventilating Engineers	New York, N. Y.	Jan. 28–30
Automotive Engineers	New York, N. Y.	Feb. 4–6
American Institute of Mining Engineers	**New York, N. Y.**	**Feb. 17–20**
New England Association of Gas Engineers	**Boston, Mass.**	**Feb. 19**
American Institute of Electrical Engineers	New York, N. Y.	Feb. 19–21
National Society for the Study of Education	Chicago, Ill.	Feb. 25–28
American Railway Engineering Association	**Chicago, Ill.**	**Mch. 18–20**

BIOGRAPHICAL NOTICES

FREDERICK G. BRENNEMAN

Frederick G. Brenneman died of pneumonia at his home at Pottsville, Pa., on November 24. He was in the class of 1912, of the Pottsville High School, attended Bellefonte Academy, and graduated from the Colorado School of Mines, at Golden, Colo., in 1916. He is survived by his parents, Mr. and Mrs. Philip Brenneman and three brothers, Louis P. and Robert C. at home, and John F., of Camp Merritt, N. J. Mr.

Brenneman had been an engineer in the copper districts of Idaho and Montana previous to his services with the New Jersey Zinc Co., and had just completed superintending the erection of the new structure near Easton for the preparation of medicated zinc oxide for the use of the U. S. Government in the treatment of gassed soldiers.

HOWARD WEIDENER DU BOIS

Howard Weidener Du Bois was born Sept. 16, 1868, and died Nov. 10, 1918. He was a graduate of the Central High School, Philadelphia, a member of the Class of 1892 of Lehigh University, and did some special work at Princeton in 1893. His work in connection with mining commenced about 1895, when, in partnership with Charles T. Mixer, he established an assay laboratory at Ishpeming, Mich., but he continued to reside in Philadelphia. From 1896 to 1904, he was professor of applied mathematics at the Central High School, Philadelphia, but during this period he spent many of his summer vacations in mining and geological exploratory work. From 1905 until his death, he was engaged in mining and exploratory work in this country, but his principal activities were in British Columbia and Alaska. In connection with work in British Columbia, he constructed a rather large hydraulic development embracing dams, ditches, and wooden stave siphons delivering water under high head. He also conducted the exploration and development of a copper property in Alaska and made a prolonged study of flotation methods in connection with the treatment of ore. He spent the summer of 1918 in Alaska in connection with work upon this property and had returned from the property only a short time before his death. In 1897, he married Miss Francis C. Higbee, of Philadelphia, and is survived by his widow, a son, and a daughter.

He will be best remembered by many of his friends for his interesting lectures on engineering subjects. He collected large numbers of photographs and pictures illustrating the fauna of British Columbia and Alaska and his lectures were replete with facts of interest both to engineers and the general public. In this way he did much to popularize mining science. He was a member of the Engineers Club of Philadelphia, Engineers Club of New York, American Institute of Mining Engineers, Mining and Metallurgical Society of America, the City Club of Philadelphia, the Lehigh Club of Philadelphia, the Princeton Club of Philadelphia, American Society of Political and Social Science, the Photographic Society, the Geographical Society, and the National Geographic Society.

FREDERIC A. HALE, JR.

Frederic Albert Hale, Jr., died at Good Springs, Nev., of Spanish influenza on November 17. At the time of his death he was manager of the Yellow Pine Mining Co. He was one of the organizers and a permanent director of the American Zinc Institute and one of the most prominent and capable engineers and mine managers of the West. Born in Denver, Colo., Jan. 28, 1888, he was graduated from the Salt Lake City High School in 1905, attended Leland Stanford Jr. University from 1905 to 1908, and graduated from the University of Utah, with the degree of B. S. in Mining Engineering, in 1910. The year 1908–09 was spent in practical work. He leaves a wife, Elizabeth Critchlow Hale, and three daughters.

HOWARD S. LEE

Howard S. Lee died of influenza at Silverton, Colo., on Oct. 25, 1918. Mr. Lee was widely known throughout Colorado and the West as a mining engineer of marked ability. He was the son of Mrs. D. K. Lee of Denver, Colo., and was born in Golden, Colo., 38 years ago. He attended the East Denver High School, Dr. Holbrook's Military Academy at Ossining, N. Y., and finished his education at Leland Stanford Junior University, where he was prominent in athletics. He was a member of the Sigma Nu fraternity and the American Institute of Mining Engineers.

Ten years ago he became associated with the United States Smelting, Refining, and Mining Co. of Boston and has been actively engaged in managing several properties of that company. Until recently he was general manager of the Leadville Unit, the vast unwatering project undertaken on Fryer Hill by the United States Co. 3 years ago. He had recently been promoted to the position of assistant to the chief consulting engineer, and expected to leave soon for his headquarters in San Francisco. His wife, Mabel Barbee Lee, and one child survive him; also a mother, two brothers, and a sister.

CLARENCE SIDNEY VERRILL

Clarence Sidney Verrill, born May 6, 1877, at New Haven, Conn., was the youngest son of Prof. Addison Emory and Flora Louise (Smith) Verrill. He prepared for Yale at Hopkins' Grammar School, New Haven, and at the Norwich Free Academy, Norwich, and entered Yale in the class of 1896, but owing to ill health had to leave college for a year; he then entered Sheffield Scientific School. During his college years, he and his father, Prof. Addison Emory Verrill, visited Bermuda, where they collected material for Prof. Verrill's books on Bermuda. Mr. Verrill's feats of diving for devil fish, clad only in an ordinary bathing suit, were printed in the magazines at that time. Another year, he undertook to finish a trip around the world on his bicycle for a magazine. This trip was begun by another man, who presumably lost his life in Turkey as nothing was ever found of him but his wheel; his itinerary took him through most of Europe and Great Britain. He was very strong and while at Yale broke all previous strength test records and was the strongest college student in America.

Mr. Verrill took a post-graduate course in mining and metallurgy at Yale and started his career as a mining engineer on the personal staff of John Hays Hammond at Stratton's Independence, Cripple Creek, Colo. When the strikes closed these mines, Mr. Verrill went to Dominica, W. I., to examine some sulfur deposits; at this time he visited practically all of that group of islands. Upon his return, he was offered the superintendency of one of the Robinson Clay Co.'s plants in Ohio. He was next offered the superintendency of a gold mine at Republic, Wash.; while there, he worked out a treatment by which 80 per cent. of the values in the ores could be extracted at a cost of less than \$2 a ton. During this time he also visited Juneau, Alaska, for some time. Just as he finished the work of running his ore tests at Republic, Mr. Wayne Darlington, general manager for the Bagdad, Chase Gold Mining Co., of Rochester, N. Y., offered him a position as his personal assistant. In January, 1907, Mr. Verrill was made assistant general manager of this company. In 1906, he married, at Los Angeles, Cal., Miss Dorothy

Lord Maltby, youngest daughter of the late George Ellsworth and Georgia Lord (Morehouse) Maltby, of New Haven, Conn. One child, a daughter, Rae Maltby Verrill, was born Sept. 2, 1907, at Soulsbyville, Cal.

In December, 1906, Mr. Verrill examined the Ajo property in Arizona and on the strength of his report the people then operating the property were enabled to proceed with their development work. He remained with the Bagdad, Chase Gold Mining Co., until May, 1908, when, the ore in the Soulsbyville mine failing, both Mr. Darlington and he resigned. He then went to Boise, Ida., where he practised as consulting engineer. During this time he and Mr. Darlington went to Cripple Creek, Colo., where they examined the Golden Cycle. In 1910, he went to Vancouver, B. C., and opened an office as consulting engineer, and with Mr. Darlington, sold the Surf Inlet gold mine to the Tonopah Belmont Co., of Philadelphia. Several years ago he became greatly interested in the Engineer mine near Atlin, B. C., and interested Mr. Darlington in it, both later going to the property. Mr. Darlington interested the Mining Corporation of Canada in this property. Mr. C. E. Watson, the manager, and Mr. J. Randolph, the engineer of this company, with Mr. Verrill, visited the property and were returning on the *Princess Sophia* when it was wrecked and every person on board was lost. Mr. Verrill was buried in Juneau, Alaska.

Mr. Verrill had great faith in the mining resources of British Columbia and believed that the various ores were there in large quantities. He was one of the Directors of the Chamber of Mines, Vancouver, and of the Belmont Canadian Mines, Ltd. He was a keen golfer and at the time of his death was a member of the Shaughnessey Heights Golf Club and the Vancouver Golf Club, Burnaby.

PIERRE DE PEYSTER RICKETTS

Pierre de Peyster Ricketts of Ricketts & Co., Inc., who died in New York on November 20, was born in Brooklyn seventy years ago. He was the son of George Robert Ashe Ricketts and Catherine Adriana de Peyster Greene. He was graduated from the Columbia School of Mines in 1871 and received his degree of Ph. D. five years later. After being an assistant in the School of Mines for several years, in 1885 he was appointed professor of assaying and in 1893 was made professor of analytical chemistry and assaying. He retired from the teaching staff in 1900 to become head of the firm of Ricketts & Banks, assayers, chemists, and consulting engineers. Dr. Ricketts' textbook, "Notes on Assaying," published in 1876, was one of the first American works on the subject and was extensively used by the colleges of the United States.

MERLE LOUIS NEBEL

Merle Louis Nebel was born in Clinton, Illinois, March 27, 1892, died October 12, 1918. He secured his preliminary education in the public schools of Clinton and in 1909 entered the University of Illinois in the course of mining engineering, graduating with the degree of Bachelor of Science in mining engineering in June, 1913. He was a member of Tau Beta Pi, Sigma Xi, and Scabbard and Blade. Immediately after graduation he was appointed as Research Fellow in Mining in the Engineering Experiment Station of the University of Illinois and continued in this

work for 2 years when he received the degree of Master of Science in Mining. During this time he made a very interesting and creditable research in connection with the specific gravity of coal, the results of which are published in Bulletin 89 of the Engineering Experiment Station. From September, 1915 to June, 1917, he was a Fellow in geology, receiving his degree of Doctor of Philosophy in geology in June, 1917. During the summers of his graduate work, he spent the time in field work in oil fields in Kansas and one summer in northern Minnesota in company with two other graduate students in Geology, gathering material for his Doctor's thesis, which was upon the subject "The Duluth Gabbro and Its Contact Metamorphism in the Vicinity of Gabimichigami Lake, Vermilion Iron-bearing District, Minnesota." Soon after receiving his Doctor's degree, he became associated with the Illinois Geological Survey and devoted most of his time to oil deposits of the state. September 1, 1918, he was appointed to a position in the Department of Geology at the University of West Virginia and had just entered upon his work when he was stricken with influenza which developed into pneumonia and to which he succumbed within ten days. He leaves a wife and two small children.

Mr. Nebel was a strong student and had an excellent personality, so that all of those associated with him foresaw that he had a brilliant future.

NEW YORK HOTEL RATES FOR THE FEBRUARY MEETING

Name	Location	Rooms With Bath		Rooms Without Bath	
		Double	Single	Double	Single
Astor	Times Square, 43d St. and Broadway	$5.00 up	$4.00 up	$4.00	$2.50 up
Belmont	42d St. and Park Ave.	6.00 up	5.00 up	5.00	3.00 up
Breslin	29th St. and Broadway	5.00 up	2.50 up	4.00 up	2.00 up
Hermitage	42d Street and Broadway	4.50 up	2.50 up	3.50 up	2.00 up
Imperial	32d St. and Broadway	4.50 up	3.00 up	3.50 up	2.50
McAlpin	34th St. and Broadway	4.00 up	3.00 up	3.50 up	2.50 up
Manhattan	42d St. and Madison Ave.	6.00 up	4.00 up	4.50 up	3.00 up
Martinique	32d St. and Broadway	4.00 up	3.00 up	3.00 up	2.00 up
Monticello	35 West 64th St.	2.50 up	2.00 up		
Navarre	38th St. and Seventh Ave	3.00 up	1.50 up	2.50 up	1.50 up
Plaza	58th St. and Fifth Ave.	6.00 up	4.00 up		
Prince George	28th St. and Fifth Ave.	3.00 up	2.00 up		
York	36th St. and Seventh Ave.	3.50	2.50 up	2.50	1.50

The monetary system of Mexico has been placed on a strictly gold basis. New gold coins now being minted are worth two and one-half pesos. Millions of pesos in silver and half-peso pieces, called "tostones," recently have disappeared from circulation. These have been demonetized to prevent speculation in the new pesos. It will be illegal for any one to give more than twenty pesos of them as change. Under the new decree, peso and half-peso pieces will be coined with less silver in them, making their exportation profitless.

LIBRARY

AMERICAN SOCIETY OF CIVIL ENGINEERS
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
AMERICAN SOCIETY OF MECHANICAL ENGINEERS
AMERICAN INSTITUTE OF MINING ENGINEERS
UNITED ENGINEERING SOCIETY
HARRISON W. CRAVER, DIRECTOR

The library of the above-named Societies is open from 9 A. M. to 10 P. M. except on holidays. It contains about 70,000 volumes and 90,000 pamphlets, including sets of technical periodicals and publications of scientific and technical societies.

Members of the Institute, with few exceptions, are forced to spend a portion of their time in localities isolated from sources of information. To these the Library, through its Library Service Bureau, can render valuable service through correspondence; letters requesting information will receive especial attention. The Library is prepared to furnish references and photographic copies of articles on mining and metallurgical subjects; to determine the existence of mining maps, and to furnish general information on the geology and mineral resources of all countries.

All communications should be made as definite as possible so that the information received may be what is desired and not include collateral matter which may not be of interest. The time spent in searching for such collateral matter will be saved, and the information will be sent more promptly and in more usable shape.

Library Accessions

ASBESTOS AND MINERAL CORPORATION. Asbestos crude and fibre, illustrations of specimens. (Gift of Asbestos and Mineral Corporation.)

CARBOLIC ACID AND ITS PRODUCTION FROM BENZOL. By Geo. H. Stevens. Newark, 1916. (Gift of Author.)

CLEANING AND ELECTRO-PLATING OF METALS. By H. H. Reama. New York, 1917. (Gift of Samuel Wein.)

MERRILL PRECIPITATION PROCESS. A brief description of methods and apparatus used in precipitating gold and silver from cyanide solutions by means of Merrillite zinc dust and other precipitants. 1918 edition. San Francisco, 1918. (Gift of Merrill Metallurgical Co.)

PRINCIPLES OF MECHANICS. Ed. 4. London, 1794. (Gift of Charles Macdonald.)

RELATION DES EXPÉRIENCES—MACHINES À VAPEUR—PLANCHES. By V. Regnault. Paris, 1847.

IMPROVED AMERICAN WATERPROOF FLOORING VERSUS GERMAN CONSTRUCTION. Paper read before the American Society of Safety Engineers. By Col. Boorman. New York, 1918. (Gift of Col. Boorman.)

EDUCATION OF MINE EMPLOYEES. By H. H Stoek. (Illinois Miners' and Mechanics' Institute. Bulletin No. 1.) Urbana, 1914. (Gift of A. D. Flinn.)

MEMORIAL OF AMOS P. BROWN. By R. A. F. Penrose, Jr. (Reprinted from the Bulletin of the Geological Society of America, v. 29, p. 13–17, 1918. (Gift of Author.)

AMERICAN SOCIETY FOR TESTING MATERIALS. A. S. T. M. Standards, 1918. Philadelphia, 1918.

ARCHIVES DES SCIENCES PHYSIQUES ET NATURELLES. Tables générales des Auteurs et des Matières. 1879–1910. Genève, 1917.

ARTHUR D. LITTLE COMPANY, INDUSTRIAL RESEARCH LABORATORIES. Descriptive Booklet. Cambridge, 1918. (Gift of Company.)

ENGLISH CATALOGUE OF BOOKS, 1917. London, 1918.

EFFICIENCY IN THE USE OF OIL FUEL. A handbook for boiler plant and locomotive engineers. Washington, 1918. (Gift of Bureau of Mines.)

OIL AND PETROLEUM MANUAL FOR 1918. By Walter R. Skinner. London, 1918.

KUNGL. TEKNISKA HÖGSKOLAN I STOCKHOLM. Program for läroaret. 1918–19. Stockholm, 1918. (Gift of Kungl. Tekniska Högskolan.)

NEW YORK STATE. State Engineer and Surveyor. Annual Report. Vol. I, 1917. Albany, 1918. (Gift of New York State Engineer and Surveyor.)

DUTCH EAST INDIES. Jaarboek van het Mijnwezen. 1915, Algemeen Gedeelte; Verhandelingen, tweede gedeelte, with atlas; 1916-Verhandelingen, tweede gedeelte. Batavia, 1917–18.

ORIENTAL CONSOLIDATED MINING COMPANY. Report for the year ending June 30, 1918. New York, 1918. (Gift of Company.)

SUPPLEMENTAL MEMORANDUM ON BEHALF OF RAY CONSOLIDATED COPPER COMPANY IN THE MATTER OF THE CLAIM OF COMPANY, Dec. 31, 1916. (Gift of Alfred D. Flinn.)

UNION OF SOUTH AFRICA. Department of Mines and Industries. Annual Report of the Government Mining Engineer, 1917. Pretoria, 1918.

U. S. COMMISSIONER OF PATENTS. Annual Report. 1917. Washington, 1918.

UNITED STATES SHIPPING BOARD EMERGENCY FLEET CORPORATION. Report on electric welding and its applications in United States of America to ship construction. By Capt. James Caldwell. Philadelphia, 1918. (Gift of Emergency Fleet Corporation.)

Book Notices

Unless otherwise specified, books in this list have been presented by the publishers. The Institute does not assume responsibility for any statements made; these are taken from the preface or the text of the book, unless otherwise noted.

COAL AND ITS SCIENTIFIC USES. By William A. Bone. (Monographs on Industrial Chemistry) Lond. and N. Y., Longmans, Green and Co., 1918. 151, 491 pp., illus., pl., charts, diags., tab., 9 × 6 in., cloth, $7.

The author, who was chairman of the British Association Fuel Economy Committee in 1915–17, has tried to give in essential outline an account of the present state of science and practice in relation to coal and its various uses. Beginning with an account of the general and scientific aspects of the coal question from a British point of view, there follows a review of the present state of science regarding the origin and chemistry of coal, including its distillation, oxidation, and combustion. The latter part of the book considers the principal economic and industrial uses of coal as a fuel, and closes with an account of surface combustion.

ELECTRIC WELDING. A Comprehensive Treatise on the Practice of the Various Resistance and Arc Welding Processes, Covering Descriptions of the Machines and Apparatus Used and the Applications, both in Manufacturing and Repair Work. By Douglas T. Hamilton and Erik Oberg. 1st edition, N. Y., The Industrial Press, 1918. 294 pp., 217 illus., 2 tab., 9 × 6 in., cloth, $2.50.

A summary of present practice. The authors announce that they have had the assistance of the most prominent American firms engaged in this work, and that they have thus been able to present information on the latest improvements and discoveries.

ENGINEERING DIRECTORY. Buyers' Reference Section. 1918 Edition. A Comprehensive Directory of Manufacturers of Mill, Steam, Mine, Plumbing, Heating and Lighting Supplies, Machinery and Tools. Chicago, The Crawford Publishing Co. (copyright 1918) 566 pp., 11 × 8 in., cloth.

This volume contains a list of American manufacturers, trade names, and brands of industrial and engineering supplies and machinery, arranged under approximately four thousand subject headings, and a directory of manufacturers. An extensive cross index to the classification is provided.

MAP READING AND TOPOGRAPHICAL SKETCHING. By Edwin R. Stuart. 1st edition. N. Y., McGraw-Hill Book Co., Inc.; Lond., Hill Publishing Co., Ltd., 1918. 11 + 139 pp., 46 illus., 1 map, 8 × 5 in., cloth, $1.

This textbook represents the results of the author's thirteen years of experience in the practice and teaching of topographic surveying and sketching at the United States Military Academy.

THE J. E. ALDRED LECTURES ON ENGINEERING PRACTICE, 1917–18. The Johns Hopkins University, Department of Engineering, Baltimore, The Johns Hopkins Press, 1918. 263 pp., illus., 2 folded pl., 1 map. 9 × 6 in., paper.

CONTENTS: Steam-electric Power Plant Design; The Relation between Civil Engineering and Military Engineering; The Development of Concrete Road Construction; Copper Refining; The Coal Problem; The Growth of Electric Systems; The Operation of a Manufacturing Plant; The Control of Stream Pollution; The Manufacture of Structural Steel.

A presentation of the tangible and obvious features and principles of present engineering practice, intended to instruct the undergraduate students of the university in everyday working methods of design, construction, and operation.

PRACTICAL SURVEYING AND FIELD WORK. Including the Mechanical Forms of Office Calculations with Examples Completely Worked Out. By Victor G. Salmon. Lond., Charles Griffin & Co., Ltd.; Phila., J. B. Lippincott Co., 1918. 204 pp., 87 illus., 3 folded diag., 8 × 5 in., cloth.

The author has endeavored to supply a series of calculations which, in connection with well-known textbooks, will equip the young surveyor for the practice of the profession. The work consists mainly of solutions to questions set in examinations for qualification as surveyors in the South African colonies. It is not intended as a textbook, and includes only the theory necessary to explain the examples.

STRUCTURAL SERVICE BOOK, Volume I. A Revised Reprint from the Twelve Issues for 1917 of The Journal of the American Institute of Architects Structural Service Department. D. Knickerbacker Boyd, Editor. Wash., The Journal of the American Institute of Architects, 1918. 16+226 pp., including industrial section, 12 × 9 in., cloth, $3.50.

The first volume of an annual review of structural activities throughout the United States with particular reference to the standards adopted or under consideration by the various societies, associations or other agencies whose work concerns itself in any way with the materials which enter into building construction, the methods and safety of their production, manufacture and erection. The material is classified and indexed for ready reference. Under each heading are lists of references to publications giving general information, describing recommended practice, and adopted standards.

HYDRAULIC EXPERIMENTS WITH VALVES, HOSE, NOZZLES, AND ORIFICE BUCKETS. Published by the Engineering Experiment Station of the University of Illinois as Bulletin 105.

Part I, by Prof. Arthur N. Talbot and Fred B. Seely, presents the results of experiments on the flow of water through 1-in. and 2-in. gate valves, 1-in. and 2-in. globe valves and 1-in and 2-in. angle valves. Part II, by Prof. Fred B. Seely, presents the results of experiments on submerged sharp-edged orifices of various shapes and sizes discharging under moderately low and under very low heads. Part III, by Prof. Virgil R. Fleming, presents the results of experiments on 1½-in. hose and nozzles, both rubber-lined and unlined linen hose being used. Part IV, by Prof. Melvin L. Enger, describes the orifice bucket as a means of measuring water and presents experimental data to indicate that the device is reliable for use in engineering practice.

Sengite is the name given an explosive recently developed in South Africa by replacing the nitrate of barium in tonite by nitrate of soda. It is safe to handle and can be struck with a steel tool. It is equivalent in power to the same weight of gelignite, but its cost is slightly greater than cost of gelignite because of the price of glycerine.

The world's demand for steel goods before the war increased the demand for pig iron from 20,000,000 tons a year 30 yr. ago to 75,000,000 tons in 1913. The world per capita consumption increased 150 per cent., England's consumption increased less than 1 per cent., America's, 300 per cent.; and Germany's, 200 per cent. Great Britain is now beating her pre-war record 50 per cent. and is dependent on the importation of 2,000,000 tons each year.

MEMBERSHIP

NEW MEMBERS

The following list comprises the names of those persons who became members during the period Nov. 9, 1918, to Dec. 10, 1918.

ALBERT, EDWARD J........................235 E. Upsal St., Philadelphia, Pa.
BARRY, D. A......Supt. of Mines, The Big Five Min. Co., Idaho Springs, Colo.
BATON, GEORGE S., Cons. Min. Engr., Baton & Elliott, 2412 First National Bank Bldg., Pittsburgh, Pa.
BAXTER, HAROLD ALEXANDER, Met. Engr. & Operation Supt., Tacony Ordnance Corpn., Philadelphia, Pa.
BENNETT, JOHN S., Chem. and Min. Engr..........Copiapó, Chile, South America.
BOWDEN, MALCOLM, Min. Engr.; Efficiency Engr., Elm Orlu Min. Co., Butte, Mont.
BROWN, HAROLD C..................................2d Lieut., A. S. A. P.
BROWN, THOMAS ALBERT, Min. and Met. Engr.; Supt., The Royal Tiger Mines Co., Breckenridge, Summit Co., Colo.
BROWN, WALTER S., Investigator, New Jersey Zinc Co. (of Pa.), Palmerton, Pa.
BURDETTE, R. S................................Capt., Ord. Dept., U. S. A.
CALLANDER, IRA C., Asst. Supt., Gauley Mountain Coal Co., Jodie P. O., Fayette Co., W. Va.
COLLINS, J. W., Foundryman, The Aluminum Castings Co., "L" Plant, Cleveland, Ohio,
COURT, ARTHUR L., Civ. & Mech. Engr., Minerals Separation North American Corpn., 220 Battery St., San Francisco, Cal.
COUSIN, JULES, Min. Engr., Union Minière du Haut-Katanga, Room 1227, 42 Broadway, New York, N. Y.
CROASDALE, STUART, Cons. Eng...................730 Symes Bldg., Denver, Colo.
CUNNINGHAM, KEITH A., Gen'l Mgr., Guanajuato Development Co., Apartado 25, Guanajuato, Gto., Mexico.
DECKER, EDWARD J., Sec'y & Mgr., Paul S. Reeves & Co., 1415 Catharine St., Philadelphia, Pa.
DRYER, T. B., Chief Engr. of Constr., Sloss Sheffield Steel & Iron Co., American Trust Bldg., Birmingham, Ala.
EDWARDS, CHARLES....Research Chem., Garfield Smelt. Co., Garfield, Utah.
EGLESTON, O. J., Chief Engr., U. S. Smelt., Refin. & Min. Co., Newhouse Bldg., Salt Lake City, Utah.
ELLIOTT, JAMES RUTHERFORD, Civ. & Min. Engr., Baton & Elliott, 2412 First National Bank Bldg., Pittsburgh, Pa.
FENTON, CLARENCE M.....Director, American Rolling Mill Co., Columbus, Ohio.
FICKES, EDWIN S., Chief Engr., Aluminum Company of America, 1269 Murrayhill Ave., Pittsburgh, Pa.
FLUMERFELT, OLIN F.......Mgr., Charles B. Bohn Foundry Co., Detroit, Mich.
FUNK, WALTER A., Min. Engr..........................Idaho Springs, Colo.
FURLONG, JOSEPH......Sales Engr., Allis Chalmers Mfg. Co., Milwaukee, Wis.
GOULD, EDGAR H., Min. Engr., White Pine Copper Co., White Pine Mine, Ontonagon Co., Mich.
GROESBECK, EDWARD C...........U. S. Bureau of Standards, Washington, D. C.
GWYER, ALFRED G. C., Met., The British Aluminum Co., Ltd., Bank Quay, Warrington, Lancs., England.
HALEY, GEORGE S. ....Gen'l Supt., A. Y. McDonald Mfg. Co., Dubuque, Iowa.
HENDRICKS, JOHN A., Geol. & Min. Engr., 126 S. Fremont Ave., Los Angeles, Cal.
HOOVER, H. EARL, Chief Engr., Hoover Suction Sweeper Co., 1407 Railway Exchange, Chicago, Ill.
JOHNSON, H. NORTON, Min. Geol., U. S. Smelt., Refin. & Min. Co., 901 Newhouse Bldg., Salt Lake City, Utah.
LEWIS, JAMES O., Supt., Petroleum Experiment Station, U. S. Bureau of Mines, Bartlesville, Okla.
LITTLE, JAMES M., Min. Engr.......................1st Lieut., Engrs., U. S. A.
MACKAY, DONALD ROBERT......Min. Engr., Baker Lead Co., Leadwood, Mo.
MEYER, RALPH A., Cons. Min. & Met. Engr., Gen'l Mgr., American Tin & Tungsten Co., Hill City, S. D.

MOFFIT, FRED H. .... Geol., U. S. Geological Survey, Washington, D. C.
MOORE, R. S. .... Chief Engr., El Paso Smelt. Wks., El Paso, Texas.
MURPHY, MARTIN F., Mgr., General Order Dept., American Locomotive Co., Schenectady, N. Y.
PETERS, C. B., Head, Explosives Section, Procurement Div., Ordnance Dept., Washington, D. C.
POOL, RALPH Y. .... Supt., Iron Silver Min. Co., Leadville, Colo.
RICHARDS, GEORGE M., Min. Engr., New Jersey Zinc Co. (of Pa.), Palmerton, Pa.
ROHMER, GABRIEL E., Engr. Met., National Lead Co., 111 Broadway, New York, N. Y.
ROWLAND, WILLIAM S. .... Chem. Engr., The Stanley Works, New Britain, Conn.
SANCHEZ, RICHARD M., School ot Mines, University of Minnesota, Minneapolis, Minn.
SPRUANCE, W. C., JR., Col., Ordnance Dept. U. S. A., Ordnance Dept., Washington, D. C.
SWOYER, W. T., Chief Engr., Southland Exploration Co., Evanston, Tenn., via Sneedville, Tenn.
TROUNCE, HARRY D., Capt., Engrs. U. S. A., 606th Engineers, Camp A. A. Humphreys, Va.
UGLOW, WILLIAM LAWRENCE, Asst. Prof. of Geol., University of British Columbia, Vancouver, B. C., Canada.
WARD, S. PAUL .... Ceramic Engr., Braden Copper Co., Rancagua, Chile.
WEBSTER, W. R., Vice-pres., Bridgeport Brass Co., 208 Brooklawn Ave., Bridgeport, Conn.
WESTERMAN, WILLIAM .... Michigan Copper & Brass Co, Detroit, Mich.
WILCOXSON, WILLIAM JAMES, Engr., Tin Smelter Wks., Straits Trading Co. Ltd., Singapore, Straits Settlements.

Associates

BALDWIN, HARRY L., Pet. Geol., Compania de Pesquisas Mineiras de Angola, Box 347, Loanda, Angola, Portuguese W. Africa.
BRISTOL, WILLIAM H. .... Pres., The Bristol Co., Waterbury, Conn.
CHANG, MING-YI, Met. Engr., American Zinc & Chemical Co., Langeloth, Pa.
CHEN, CHUNG-YANG .... Student, Columbia University, New York, N. Y.
DAVILA, MARINO, Min. Engr. .... Jorge Juan 15, Madrid, Spain.
ENDWEISS, J. A., Gen'l Mgr., Guanajuato Development Co., Apartado 25, Guanajuato, Gto., Mexico.
FISCHER, CHRISTIAN J. G., Pres., Fischer-Sweeney Bronze Co., Inc., 13th & Grand St., Hoboken, N. J.
GOHEEN, JOHN F., Sec'y, The Brown Instrument Co., 6120 McCallum St., Philadelphia, Pa.
HANSER, HUGO E., Min. & Mech. Engr. .... 93 Miller Ave., Brooklyn, N. Y.
HARRIS, WILLIAM G., Pres., The Canada Metal Corpn., 35 Fraser Ave., Toronto, Ont., Canada.
HOYT, C. E. .... Lewis Institute Bldg., 1951 W. Madison St., Chicago, Ill.
JONES, PAUL .... Asst. Purchasing Agent, Air Nitrates Corpn., New York, N. Y.
KINSEY, W. E. .... Kinsey & Mahler Co., Peoria, Ill.
LANGSENKAMP, WILLIAM, Vice-pres. & Supt., The Langsenkamp-Wheeler Brass Wks., 1234–1266 Shelby St., Indianapolis, Ind.
LANZA, ANTHONY J., Chief, Division Industrial Hygiene & Medicine, U. S. Public Health Service, 201 Ouray Bldg., Washington, D. C.
LEEKE, DANA WINSTON, Asst. Supt., Surveying & Ore Estimation Dept., Seoul Min. Co., Tul Mi Chung Mine, Whang Hai Province, Nantei, Korea.
LINDEMER, CHARLES ...... Supt., J. L. Mott Co., 232 Chestnut Ave., Trenton, N. J.
LISSBERGER, M. .... B. Lissberger & Co., Woolworth Bldg., New York, N. Y.
MCCALLUM, JOHN C. .... Supt., Titanium Bronze Co., Inc., Niagara Falls, N. Y.
O'BRIEN, D. F., Pres. & Gen'l Mgr., The A. P. Smith Mfg. Co., East Orange, N. J.
PARTRIDGE, NELSON H., Mining .... 701 E. & C. Bldg., Denver, Colo.
RAY, FRANK S. .... Bridgeport Crucible Co., Bridgeport, Conn.
REARDON, W. J. .... Foundry Supt., Rome Mfg. Co., Rome, N. Y.
RIX, HARRY L., Brass Foundry Foreman, British Westinghouse, Trafford Park, Manchester, England.
ROBERTS, T. H., Factory Mgr., The Roberts Brass Mfg. Co., 1411 West Fort St., Detroit, Mich.
RYDER, PARMLY H. .... Ryder Brass Co., Bucyrus, Ohio.

SHIDEL, H. R., Geol., Oil & Gas Production, Empire Gas & Fuel Co., Augusta, Kansas.
SMITH, HERBERT, Gen'l Supt., Jenkins Bros., Ltd., St. Remi St., Montreal, Canada.
STRAUB, J. W., Vice-pres., The Morton B. Smith Co., 241–43 Front St., New York, N. Y.
SWIFT, FRANK G., Supt. & Partner, Swift Lubricator Co., 729 West 2d St., Elmira, N. Y.
TOWNSEND, JAMES H., Min. Engr., J. H. Townsend Co., Higgins Bldg., Los Angeles, Cal.
VICKERS, CHARLES, Specialist, Non-ferrous Alloys, 18 Dun Bldg., Buffalo, N. Y.
WRAY, CHARLES F., Sec'y & Treas., Henry Wray & Son, Inc., 195 Mill St., Rochester, N. Y.

Junior Associates

EVERIT, RICHARD STURTEVANT, Student, Heavy Artillery Officers' Training Camp, Fort Monroe, Va.
PARKER, RUSSELL J.........Student, Colorado School of Mines, Golden, Colo.

Change of Status—Junior Associate to Associate

VOGEL, HERMAN H., Medical Replacement Unit No. 35, Overseas Casuals, Camp Merritt, N. J.

Total Membership, Dec. 10, 1918............................ 7285

CHANGE OF ADDRESS OF MEMBERS

The following changes of address of members have been received at the Secretary's office during the period Nov. 9, 1918 to Dec. 10, 1918.

This list together with the list published in Bulletins No. 133 to 144, January to December, 1918, and the foregoing list of new members, therefore, supplements the annual list of members corrected to Jan. 1, 1918 and brings it up to the date of Dec. 10, 1918.

ADAIR, ARTHUR C., Corp., 4th Co. 1st Training Bat., 154th Depot Brigade, Camp Meade, Md.
ADAMS, HUNTINGTON..................................Antofagasta, Chile.
ADAMS, L. W..........................Ashland Iron & Min. Co., Ashland, Ky.
AGNEW, JAMES C., Midvale Steel & Ordnance Co., Widener Bldg., Philadelphia, Pa.
ALLEN, ROY H.............................27 Bellevue Ave., Dayton, Ohio.
ARNOLD, C. E. LEN.................Cons. Arizona Smelt. Co., Mayer, Ariz.
AUBEL, V. W.......Asst. Blast Furnace Supt., Carnegie Steel Co., Clairton, Pa.
AUSTIN, L. S.........................630 S. Alvarado St., Los Angeles, Cal.
BAKER, JOHN M.........................1212 E. Colfax Ave., Denver, Colo.
BATCHELLOR, STILLMAN, 1st Lieut., Co. 6, E. O. T. S., Camp A. A. Humphreys, Va.
BEAUCHAMP, H. C...............................Box 68, Douglas, Ariz.
BENT, QUINCY..........................Bethlehem Steel Co., Bethlehem, Pa.
BERTHIER, U. H., Asst. Supt., Lead & Copper Smelter, Compania Metalurgica de Torreon, S. A., Torreon, Coah., Mexico.
BJORGE, GUY N.......................Co. 3, E. O. T. S., Camp Humphreys, Va.
BLUM, EDWARD H., Atlantic Oil Producing Co., 808 American Exchange National Bank Bldg., Dallas, Texas.
BOWMAN, J. V..........................Care Tacoma Smelt. Co., Tacoma, Wash.
BOYLE, HARRY, Chief Inspector, United States Fuel Administration, Lyon Bldg., Seattle, Wash.
BRADLEY, D. H., JR., Capt., Engr. Corps, U. S. A., 428th Engineers, Camp Cody, New Mexico.
BRINTON, OWEN F...................................Baxter Springs, Kansas.
BROOKS, ALFRED H., Lieut.-Col., Engrs., G. H. Q., American E. F., Care Postmaster, N. Y.
BROWN, WILLIAM N................1517 H. St., N. W., Washington, D. C.
BRULÉ, FREDERICK J., Constr. Dept., Braden Copper Co., 120 Broadway, New York, N. Y.

BUTLER, R. S. . . . . Asst. Mgr., Union Metal Mines Co., Joplin, Mo.
BUTNER, DANIEL W., Lieut., Co. E, 27th Engineers, American E. F., Care Postmaster, N. Y.
BYER, HERMAN E., Care United Security Life Insurance & Trust Co., 605 Chestnut St., Philadelphia, Pa.
CARLTON, DAVE P., Sgt., Army Engr. School, American E. F., Care Postmaster, N. Y.
CARNEY, FRANK D. . . . . Carney & Lindemuth, 40 Wall St., New York, N. Y.
CARPENTER, BYRON H. . . . . 41 The Savoy, 14th St., N. W., Washington, D. C.
CARTWRIGHT, F. O. . . . . Instructed to hold everything.
CARY, WEBSTER C., Cons. Engr., Climax Molybdenum Co., 822 Foster Bldg., Denver, Colo.
CHEN, T. C., Blast Furnace Engr., The Yangtse Engineering Wks., Seven Mile Creek, Near Hankow, China.
CLAYTON, CHARLES Y., Dept. Met. & Ore Dressing, Missouri School of Mines, Rolla, Mo.
COFFEY, GEORGE W., 2d Lieut., Co. C, 27th Engineers, American E. F., A. P. O. 774, France.
COLBURN, C. LORIMER . . . . Capt., 140th Engineers, Camp Shelby, Miss.
COLE, A. N. . . . . Care Deposit National Bank, DuBois, Pa.
CRAMPTON, THEODORE H. M. . . . . 1501 West Monroe St., Phoenix, Ariz.
CUSHING, DANIEL . . . . Capt., Air Service, U. S. Army.
CUTLER, WILLARD W., JR. . . . . 2 Cutler St., Morristown, N. J.
DEWITT, H. A. . . . . Min. Engr., Colorado Min. Co., Arroyo, Masbate, P. I
DIXON, P. ST. JOHN, Supt., Papa-Cobras Mine, Rua Visconde de Inhauma, 81, Rio de Janiero, Brazil.
DOYLE, JOHN J., 2d Lieut., Co. D, 313th Engineers, American E. F., Care Postmaster, N. Y
DUGGLEBY, A. F., 2d Lieut., Engrs., Army Engineers School, American E. F., Care Postmaster, N. Y.
EATON, W. J., Cia. Minera Paloma y Cabrillas, S. A., Higueras, Coah., Mexico.
EBERHARDT, WILLIAM G. . . . . 529 Hawley Ave., Bridgeport, Conn.
FARNHAM, LLOYD L. 1024 Quincy St., Rapid City, So. Dak.
FELL, HAROLD B. . . . . Major, 73d Field Artillery, Camp Jackson, S. C.
FIELD, FREDERICK M. 2118 Crenshaw Bldg., Los Angeles, Cal.
FORBES, CARROLL R. . . . . Major, 217th Engineers, Camp Beauregard, La.
FOX, WALTER V. . . . . Mgr., Ward Min. & Mill. Co., Box 202, Quapaw, Okla.
FRENCH, R. W. . . . . Ingot, Cal.
FREUDENBERG, W. H. . . . . E. O. T. S., Camp Humphreys, Va.
FULTON, CHESTER A., Supt., Carlota Mine, Cumanayagua, Provincia Santa Clara, Cuba.
GALBRAITH, CHARLES S., Sapper No. 52526, Australian Engineers Depot, Brightlingsea, Essex, England.
GANTER, GEORGE A. . . . . 118 West 71st St., New York, N. Y.
GAUTHIER, CHARLES B., Naval Aviator, Naval Officers' Reserve Flying Corps, U. S. A.
GEIB, FRANCIS HODGSON . . . . 1055 Mariposa St., Denver, Colo.
GOLDSMITH, OSHER, Cand. F. A. C. O. T. S., 22d Training Battery, Camp Zachary Taylor, Ky.
GRAUPNER, M. F. . . . . Reichle P. O., Glen Station, Mont.
GREENAN, J. O., 2d Lieut., Headquarters 27th Engineers, A. P. O. 774, American E. F., France.
GRIMES, JOHN A., 1st Lieut., Ordnance Section, Statistics Branch, General Staff, Room 119, State, War & Navy Bldg., Washington, D. C.
GROSS, LEROY M. . . . . 410 Riverside Drive, New York, N. Y.
HAFF, RAYMOND E. T., Engrg. Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.
HAGER, LEE . . . . 28 Rossonian Apts., Houston, Texas.
HAMMITT, E. P., Lieut., 319th Engineers, American E. F., Care Postmaster, N. Y.
HARDY, R. A. . . . . Care Thana Ranch, Fallon, Nev.
HAURY, P. S. . . . . Silver State Mines Co., Lower Rochester, Nev.
HAYWARD, MARDEN W. . . . . 247 South Ardmore Ave., Los Angeles, Cal.
HEALY, RALPH L. . . . . Kennicott, Alaska.
HILL, JOSEPH H. . . . . Co. D, 209th Engineers, Camp Sheridan, Ala.
HONNOLD, W. L., Care Guaranty Trust Co., 1 and 3 Rue des Italiens, Paris, France.
HUBBART, C. C. . . . . U. S. Fuel Co., Westville, Ill.
HURD, RALPH, Ontario-Kirkland Gold Mines, Ltd., Kirkland Lake, Ont., Canada.

HUTCHINSON, JOSEPH H. .... Overland Hotel, Reno, Nev.
IDDINGS, ARTHUR .... Geol., Hanover, Ind.
JOHNSTON, JOHN ...... National Research Council, 1023 16th St., Washington, D. C.
KEILLER, ALEXANDER G. .... Instructed to hold everything.
KEPNER, ROSS B. .... Mina Reforma, Estacion San Juan, Coahuila, Mexico.
KING, ROWLAND, 1st Lieut., Engrs., Camp Headquarters, Camp A. A. Humphreys, Va.
KISHMAN, MAURICE W. .... 1st Lieut., E. O. T. C., Camp A. A. Humphreys, Va.
KITSON, H. W., Ensign (T) U. S. N., U. S. S. Delaware, Care Postmaster, N. Y.
KLEPINGER, JOHN H. .... Brookston, Ind.
KNEATH, WATKIN W. .... 1453 Ridge Ave., Evanston, Ill.
LACROIX, MORRIS F., Major, Engrs., 1st Army, American E. F.,
Care Postmaster, N. Y.
LASIER, FREDERICK G., Capt., Engrs., Room 4-336 Office, Chief of Engineers,
War Dept., Washington, D. C.
LAWR, C. W. .... General Delivery, Douglas, Ariz.
LAWRENCE, WILLIS, Mgr., Estaca Mines, Mexican Candelaria Co., S. A.,
Care Escobosa, Burns y Cia., San Ignacio, Sinaloa, Mexico.
LEACH, ROY .... Care Duana Johnson, Fortuna, Cal.
LEDNUM, E. T., Mgr., E. I. du Pont de Nemours & Co., Ideal Bldg., Denver, Colo.
LEWIS, C. M. .... 802 Arctic Bldg., Seattle, Wash.
LEWIS, ROBERT S. .... University of Utah, Salt Lake City, Utah.
LEWIS, W. FRANK .... Major, Engrs., U. S. A., Camp A. A. Humphreys, Va.
LEWYN, OSWALD M. .... Guggenheim Bros., 120 Broadway, New York, N. Y.
LINDEMUTH, LEWIS B. .... Carney & Lindemuth, 40 Wall St., New York, N. Y.
LONGWORTH, F. J. .... Tennessee Copper Co., Copperhill, Tenn.
LYNCH, WILLIAM W., 27th Engineers, American E. F., Care Postmaster, N. Y.
LYNTON, EDWARD D. .... Ensign, U. S. S. Vicksburg, San Diego, Cal.
MCNABB, JAMES C. .... Asst. Smelter Supt., Missouri Cobalt Co., Fredericktown, Mo.
MABEN, J. C., JR. .... 407 American Trust Bldg., Birmingham, Ala.
MAVERICK, PHILLIP, Testing Engr., Greene Cananea Copper Co.,
Cananea, Son., Mexico.
MEE, WHITNEY P., Chief Chem., Matehuala Plant, American Smelt. & Refin. Co.,
Matehuala, San Luis Potosi, Mexico.
MEIER, A. J. .... A. J. Meier & Co., 1900 Morgan St., St. Louis, Mo.
MERRITT, FLOYD C. .... U. S. Army, Camp Humphreys, Va.
METZ, GILBERT F. .... Ensign, U. S. S. President Grant, Care Postmaster, N. Y.
MILLARD, WILLIAM J., Capt., Engrs., G-4 Second Army, American E. F.,
Care Postmaster, N. Y.
MITCHELL, THOMAS E., Min. Engr., Burma Mines, Ltd., No. 1 London Wall Bldg.,
London, E. C., England.
MOGA, JOHN AUGUST .... 271 Charles St., St. Paul, Minn.
MOORE, STANLEY R. .... New Denver, B. C., Canada.
MORGAN, GEORGE H., Capt., Engrs., 5th Corps, American E. F.,
Care Postmaster, N. Y.
MORSE, H. W. .... Technical Mgr., American Trona Corpn., Trona, Cal.
MOULE, J. W. .... Asst. Mgr., Burma Corpn., Ltd., Namtu, Burma, India.
MUIR, DOWNIE D., JR., Mgr., Kansas Oklahoma Mines,
U. S. Smelt., Refin. & Min. Co., Box 542, Baxter Springs, Kansas.
MURPHY, WILLIAM J. ...... 2d Lieut., 5th Prov. Bat., Fort Benjamin Harrison, Ind.
MUSGRAVE, ROBERT .... Moctezuma Copper Co., Nacozari, Sonora, Mexico.
NEUSTAEDTER, HAROLD A. .... Erie Proving Grounds, Ohio.
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San Juancito, Honduras, C. A.
PEARSON, ALFRED, JR. .... Somerset, Pa.
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RENWICK, CHARLES W. .... Mountain Ash, Ky.
RICHELSEN, WALTER A., 1st Lieut., 428th Engineers, U. S. A., Camp Humphreys, Va.
RICKARD, BRENT N. .... American Smelt. & Refin. Co., Murray, Utah.

ROBBINS, O. D....................Armour Fertilizer Wks., Columbia, Tenn.
ROBERTS, J. K.........Instructor in Geol., Emory & Henry College, Emory, Va.
ROBERTS, MORGAN E., 2d Lieut., Engrs., Transportation Service, Advance Section, Headquarters Co., 60th R. T. C., A. P. O. 758, France.
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SANDS, W. E...McGill, Nev.
SANFORD, CHARD O...........1st Lieut., 403d Engineers, Fort Douglass, Utah.
SCHEURER, L. R.....................Co. E, E. O. T. C., Camp Humphreys, Va.
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SEEBER, REX ROBERT..................Dalhousie, New Brunswick, Canada.
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SHEAFE, HARRY J., Capt., Division Gas Officer, 82d Division, American E. F., Care Postmaster, N. Y.
SHIMMIN, J. T.......Supt., Arizona-Hercules Min. Co., Belgravia, Pinal Co., Ariz.
SIMKINS, WILLIAM A., 2d Lieut., Engrs., Army Engineer School, American E. F., Care Postmaster, N. Y.
SKEEN, LESLIE C., 2d Lieut., Co. 13, 104th Engineers, American E. F., Care Postmaster, N. Y.
SMITH, HARVEY E., Cia. Carbonifera "Las Rias de Curanilabue," Curanilabue, Chile.
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STAVER, W. H.............................Instructed to hold everything.
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STODDARD, A. C., Min. Engr., Inspiration Cons. Copper Co., Box 15, Inspiration, Ariz.
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SWEETSER, ARTHUR L., Min. Engr., Editorial Staff, *Engineering & Mining Journal*, 10th Ave. & 36th St., New York, N. Y.
TANDY, CHARLES W., JR., Designing Engr., Anaconda Copper Min. Co., Anaconda, Mont.
TAO, H. T...............Student, Michigan College of Mines, Houghton, Mich.
TAYLOR, CARROLL C.............Capt., 32d Artillery, C. A. C., Camp Eustis, Va.
TAYLOR, HENRY B., Min Engr................310 Long Bldg., Kansas City, Mo.
THOENEN, J. R..................................Elizabethtown, Ill.
THOMAS, KIRBY......................70 Central Park W., New York, N. Y.
THOMAS, PERCY C., Gen'l. Mgr., East Gulf Coal Co., East Gulf, Raleigh Co., W. Va.
THOMPSON, WARREN D................Co. 3, E. O. T. S., Camp Humphreys, Va.
THORNHILL, E. BRYANT...............Chino Copper Co., Hurley, New Mexico.
TIMMONS, COLIN......................1321 West 46th St., Los Angeles, Cal.
TREMOUREUX, ROY E., 1st Lieut., Engrs., G. H. Q., American E. F., Care Postmaster, N. Y.
VAN SICLEN, MATTHEW, 1st Lieut., A. S. A., Damm Field, Babylon, L. I., N. Y.
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WAITE, ALLAN G., Capt., Air Service, Aeronautics, Office of Director Military Aeronautics, Washington, D. C.
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WARREN, S. POWER..........Met. Staff, Utah Copper Co., Salt Lake City, Utah.
WELLS, JAMES S. C., Met. & Chem......................Bedford Hills, N. Y.
WERTHAN, S. E., Chemical Warfare Service, American University Experiment Station, Washington, D. C.
WERTHEIMER, JOSEPH, Tech. Director, Heat Treating Dept., Watervliet Arsenal, Watervliet, N. Y.
WIEGAND, AUGUST J., Co. F, 309th Engineers, American E. F., Care Postmaster, N. Y.
WILLISTON, GEORGE F., Artillery Officers' Training Camp, 1st Co., Fort MacArthur, San Pedro, Cal.
WINCHELL, J. H., JR., U. S. Geological Survey, Room 4211, Interior Bldg., Washington, D. C.
WOLVERTON, F. M.............Student, Co. 4, E. O. T. S., Camp Humphreys, Va.

WOODS, CLARENCE..........Supt., Dragoon Tungsten Min. Co., Dragoon, Ariz
WOODWELL, A. H..................................Box 1720, Spokane, Wash.
WYANT, FRANK A., United Coal Corpn., 1st National Bank Bldg., Pittsburgh, Pa
ZIMMER, ERNEST B., Met., Cleveland District Ordnance,
22d & Prospect Ave., Cleveland, Ohio
ZOLLER, LAWRENCE J., 2d Lieut., Co. B, 603d Engineers, American E. F.,
Care Postmaster, N. Y

MEMBERS' ADDRESSES WANTED

Name. Last address of Record from which Mail has been returned.

ARMSTRONG, CLIFTON T................347 Manhattan Ave., New York, N. Y.
ARMSTRONG, E. W.................Mina Bibilonia, La Libertad, Nicaragua, C. A.
BIRD, FRANK H..............................Butler Hotel, Seattle, Wash.
BLANCHARD, RALPH C...................3 Lombard St., London, England.
BREEDING, F. O....................Eden Min. Co., Bluefields, Nicaragua.
BRYANT, GEORGE W....................Apartado 86, Guanajuato, Gto., Mex.
DETERT, WILLIAM F............................Jackson, Amador Co., Cal.
FRASER, EVERETT L...................Oro Grande Mines, Callahan, Cal.
HERR, J. CAMPBELL...............................Box 556, State College, Pa.
HESS, K. F........................Burro Mountain Copper Co., Tyrone, N. M.
HUNTER, CHARLES, Royal Colonial Institute, Northumberland Ave., London, W., England.
HURUM, FREDRIK J. O.................Westmorley Court, Cambridge, Mass.
KAMMERER, CHARLES.......................Box 412, San Francisco, Cal.
KAY, DAVID NELSON..................Ray Cons. Copper Co., Hayden, Ariz.
KING, FRANK E..........................Hotel Breslin, New York, N. Y.
KLEESATTEL, RICHARD........................911 White Bldg., Seattle, Wash.
KLÜGESCHEID, WALTER P................616 W. 113th St., New York, N. Y.
MILLER, HARRY H........................37 So. Stone St., Tucson, Ariz.
NICHOLSON, FRANCIS..........................Charlotte Court House, Va.
RALEIGH, JOSEPH R...........Rossville, via Cooktown, Queensland, Australia.
STICKNEY, WILLIAM H..........................708 N. Center St., Reno, Nev
TAPLIN, THOMAS J., JR.............16 Lordship Park, London N. 16, England.
TREAT, LLOYD B., Canadian Ingersoll-Rand Co., Bank of Toronto Bldg., Montreal, Canada.
WILLIAMS, JOHN T.........................100 Broadway, New York, N. Y.
WONG, S. C...........................Care School of Mines, Butte, Mont.
WONG, YIN CHARLES..Rolla, Mo.
WOO, W. K...........M 70 Sing Kong Li, Minghong Road, Shanghai, China.
YEWELL, P. R., Leland Stanford, Jr., Univ., Box 1212, Stanford University, Cal.

NECROLOGY

(See also "Died in Service")

The deaths of the following members were reported to the Secretary's office during the month Nov. 9, 1918, to Dec. 10, 1918.

Date of Election.	Name.	Date of Death.
1905	Boschen, William C.	Nov. —, 1918.
1916	Brenneman, F. G.	Nov. 30, 1918.
1915	Brooks, Charles P.	Nov. 30, 1918.
1906	Cook, Edward B.	Oct. 13, 1918.
1905	Crespi, R. A.	Sept. 2, 1918.
1894	Du Bois, Howard W.	Nov. 10, 1918.
1892	Gilbert, G. K.	————
1914	Hale, Frederic Albert, Jr.	Nov. 17, 1918.
1913	Lunn, Robert, Jr.	Killed in action.
1915	Ohnsorg, N. L.	Oct. 10, 1918.
1873	Ricketts, P. de P.	Nov. 20, 1918.
1916	Thomas, R. P.	——— 1918.
1900	Van Hise, Charles R.	Nov. 19, 1918.
1918	White, Bruce	Nov. 15, 1918.

CANDIDATES FOR MEMBERSHIP

APPLICATION FOR MEMBERSHIP.—The Institute desires to extend its privileges to every person to whom it can be of service. On the other hand, it is not desirable that persons should be admitted to membership in classes for which they are not qualified. Members of the Institute can be of great service if they will make a practice of glancing through the list of applicants and promptly notifying the Committee on Membership, or the Secretary of the Institute, of any persons whom they think should not be classified in accordance with the list given.

Applications Lacking Endorsement

Applications for membership have been received from Mr. Braecke and Mr. Brink, whose records are given below. These applications lack the necessary number of endorsers, but since these candidates live at some distance from the headquarters of the Institute, their records are published here in order that any members who are acquainted with them may be advised of the circumstances and may have an opportunity of writing to the Secretary endorsing these candidates.

Members

Gustave Braecke, La Carolina, Spain.
Proposed by A. DeDeken.
Born 1860, Nieuport, Belgium. 1886, Grad., School of Mines, Liége, Belgium, M. E. and Engr. of Arts and Manufactures. 1887–91, Ore-dressing Dept., Humboldt Engng. Works, Kalk, Germany. 1891–1901, Prospecting, Northern Transvaal; Mgr., Molyneux mines, Witwatersrand, Transvaal. 1901–03, Mgr., Gwendoline gold mine, Korea. 1903–06, Mgr., Mina San Vicente, Société la Nouvelle Montagne, Spain. 1906–07, Prospecting for zinc, Djendli mine, Arzelia. 1907–11, Mgr., Ollin mines, North Spain. 1911–13, Reporting in Spain for Société d'Etudes Minière, Brussels. 1914–18, Mgr., Lead mines, Curas and Soldado, and Technical Mgr., New Cerdenillo, silver-lead mines, La Carolina, Spain.
Present position: Mgr., Société Curas et Soldado de Carolina.

Cyril Gordon Brink, Transvaal, So. Africa.
Born 1889, Grahamstown, So. Africa. 1900–05, High School. 1906–07, St. Andrews School. 1908–09, Chem., Rhodes Univ., Grahamstown. 1910–15, In Reduction Wks., Norse Gold Mines, Ltd., Johannesburg. 1915–17, Leading Shiftsman, and in chg. of reduction wks., Fairview gold mine, Transvaal Cons. Mines.
Present position—1917 to date: Reduction Officer, Fairview Devonian Montrose Gold Mines, Ltd.

The following persons have been proposed during the period Nov. 9, 1918, to Dec. 10, 1918, for election as members of the Institute. Their names are published for the information of Members and Associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Board of Directors, which has the power of final election.

Rolland Croten Allen, Lansing, Mich.
Proposed by H. A. Buehler, Ralph Arnold, E. W. Shaw.
Born 1881, Richmond, Ind. 1907, Grad. in geology, Univ. of Wisconsin, B. A. and M. A. 1904, Geological field work, Ontario, Canada. 1904–5, Student Asst., in geology, Univ. of Wisconsin. 1905, Field Asst., U. S. Geol. Survey. 1906–7, Geol. field work, Ontario, Michigan and Minnesota. 1908–9, Instr. in Geol. 1909–13, Special Lecturer in geology, Univ. of Michigan. 1909–18, State Geol. of Michigan. 1912–18, Appraiser of Mines, Mich. 1914–18, Advisor to Michigan Securities Co.
Present position: State Geol. of Mich., and Appraiser of Mines, U. S. Treasury.

Charles Luther Austin, Bingham Canyon, Utah.
Proposed by F. G. Janney, Perry G. Harrison, Arno S. Winther.
Born 1884, Saginaw, Mich. 1907, Miner and assayer. 1907–08, Mining and milling at Cons. Mercur mine. 1908–10, Mining at different mines in Pioche, Nev.
Present position—1910 to date: Chief Chem. and Assayer, Utah Min. Co.

Arthur James Bartlett, Goodwell, W. Va.
Proposed by Thomas H. Clagett, S. A. Scott, P. C. Thomas.
Born 1890, England. 1905, Finished Public Schools, Cardiff, Wales. 1906–12, With engineering party and became Asst. Transitman, Kingston Coal Co., Kingston, Pa. 1912, Min. Engr., Middle State Coal & Coke Co., Ansted, W. Va. 1912–13, Div. Engr., Pon Creek Coal Co., Stone, Ky. 1913–14, Asst. Supt. and Engr., Jewel Ridge Coal Corpn., Va. 1914–15, Mine Foreman, Scarbro Shaft, New River Co., McDonald, W. Va. 1915–17, With Solvay Collieries Co., Min. Engr., later, Div. Engr.
Present position: Chief Engr., Louisville Coal & Coke Co.

Arthur John Bensusan, Minas Geraes, Brazil.
Proposed by Fred Hellman, C. R. Corning, B. B. Thayer, J. Parke Channing.
Born 1868, Australia. 1888–92, Grad., Min. and Met., Royal School of Mines, London, Assoc. R. S. M. 1885–88, Asst. Assayer, Chief Assayer, Sunny Corner Silver Min. Co., Ltd.; Asst. to Mgr., Mgr., Butters Tin Min. Co., Ltd., and Dolcoath Tin Min. Co., Ltd., Australia. 1894, Mgr., Port Darwin Tin Min. Co., Ltd., N. S. W. 1894–1901, Member of firm, E. & A. Bensusan, Cons. Min. and Met. Engrs., Sydney, with management of Cullen Bullen Coal Proprietary, Ltd., Mt. Dromedary Gold Min. Co., Ltd., Great Britain gold mine and other mining properties. 1902–03, Gen'l Mgr., Abboutiakoon Wassaw Mines, Ltd.; Effuenta Wassaw Mines, Ltd.; Tante Mines, Ltd., West Africa. 1903–04, Gen'l Mgr., Zoutpansberg Cons. Mines, Ltd., Transvaal. 1904–05, Worked for and won diploma, Royal Geographical Society, in topographical surveying.
Present position—1905 to date: Gen'l Mgr., Ouro Preto Gold Mines of Brazil, Ltd.

George Vanderbilt Caesar, Plainfield, N. J.
Proposed by Charles Ferry, C. H. Mathewson, Wm. B. Price.
Born 1891, Tacoma, Wash. 1910–16, Yale Univ., S. S. S., Ph. B. and M. S. 1915–16, Research work at Yale Univ., in non-ferrous metallography. Paper on "Annealing Properties of Copper." 1916–18, Asst. Metallographist in laboratory, Bridgeport Brass Co.
Present position: Met. and Head, Metal Room and Casting Shop Depts., British American Metals Co.

R. J. Colony, New York, N. Y.
Proposed by Charles P. Berkey, James F. Kemp, R. M. Raymond.
Born 1870, St. Louis, Mo. 1897–1905, Cooper Union, B. Ch. 1905, 1913–16, Non-matriculate student in geol., Columbia Univ., New York. 1889–93, Asst. Chem. and Assayer, Omaha & Grant Smelt. & Refin. Co., Omaha, Neb. 1892–93, Supt., experimental cyanide plant, Lead City, So. Dak. 1893–96, Ore Buyer, La Gran Fundicion Nacional Mexicana. 1896–1900, Railway Equipment Co., New York. 1900–05, Instructor, Assaying and Mineralogy. 1905–16, Asst. Prof., Cooper Union, New York.
Present position—1916 to date: Instructor in Geol., Columbia Univ.

Robert Henry Crozier, Kuridala, N. Q., Australia.
Proposed by Thomas I. Dyson, G. C. Klug, John W. Moule.
Born 1884, Australia. Caulfield Grammar School, Melbourne. 1902–03, Melbourne School of Mines (W. M. C.). 1904–07, Diploma Met. Chem., Zechan School of Mines. 1903–07, Assayer, Tasmanian Smelt. Co. 1907–08, Assayer, Chillagoe Smelt. Plant, Queensland. 1908–10, Assayer, Phillips River Gold & Copper Co., West Australia. 1910–11, Assayer, Murex Magnetic Co., Broken Hill, New South Wales. 1911–12, Gen'l Mgr., McArthur River Exploration Co., Northern Territory. 1912–13, Exam. prospects, Nor-West Syndicate, West Australia. 1913–17, Research Met., Minerals Separation and DeBavay's Processes (Aust.) Proprietary, Ltd., Melbourne.
Present position—1917 to date: Mill Supt., Hampden Cloncurry Copper Mines, Ltd.

Lewis Colvin Doty, Eureka, Utah.
Proposed by J. H. McChrystal, C. C. Griggs, J. C. Dick.
Born 1859, Ashland, Ohio. Common and High Schools; International Correspondence School. 1884–90, Mining and leasing, Leadville, Colo. 1890–92, Supt., Eureka Cons. Mine, Eureka, Utah. 1893, Gemini Min. Co., Eureka, Utah. 1894–97, Foreman and Supt., Eureka Hill Min. Co. 1898–1900, Mgr., Apex Min. Co., Eureka, Utah. 1901, Supt., Ely Min. & Mill. Co., Ely, Nev. 1902–17, Supt., Giroux Cons. Mine, Ely, Nev.
Present position: Supt., Bullion Beck & Champion Min. Co.

Sherman B. Eaton, Dover, N. J.
Proposed by H. M. Roche, J. C. Stoddard, Thomas E. Fisher.
Born 1891, Crown Point, N. Y. 1912–15, Investigation of magnetic properties of iron and steel, General Electric Co. 1911–12, General surveying. 1915–16, Magnetometric investigation, magnetite mines, Essex Co., N. Y. 1916, Magnetometric investigations of iron ores, Ashe Co., N. C.; magnetometric survey, property of Renard, Arizona Min. Co., Casa Grande; Mitchell Co., M. C.; magnetometric survey, Lake Co., Minn. 1916–17, Construction and management, manganese washing plant, Sugar Grove, Va.
Present position—1917 to date: In charge, magnetometric surveys, Wharton Steel Co.

John Henry Eby, Spokane, Wash.
Proposed by Everett H. Pattison, L. K. Armstrong, J. C. Haas.
Born 1872, Lancaster, Pa. 1894, Grad., Michigan College of Mines, E. M. 1894–95, Engr. on construction, Penn. Traction Co. 1895–97, Min. Engr., Minn. Iron Co., London, Minn. 1897–98, Asst. Supt., Columbia Menava mine, Smuggler, Colo. 1898–1903, South. Pac. R. R., Instrument man, Asst. Engr., M. of W. and Roadmaster. 1903–05, Asst. Roadmaster, R. F. & P. R. R. 1905–07, Location Engr., Harriman Interests, A. & C. R. R., Durango, Colo., and Gallup, N. M. 1907–10, Private practice, min. engrg. 1910–15, Supt., Virginia mine, Virginia, Minn.
Present position—1915 to date: Private practice, min. engrg.

Edward August Engelhardt, Philadelphia, Pa.
Proposed by Winthrop C. Neilson, K. C. Parrish, Joseph T. Hilles.
Born 1891, Sheldon, Ia. 1906–11, Westminster College, Fulton, Mo., B. S.; 1912–13, Post Graduate Course. 1911–12, Teacher, Chem. and Physics, Hot Springs, Ark., High School. 1907–11, Asst., Chem. Dept., Westminster College. 1913–15, Chem. and research man, Aluminum Ore Co., E. St. Louis, Ill.
Present position—1915 to date: Chief Chem. and Supt., Exploration Republic Min. & Mfg. Co.

David M. Good, Williamson, W. Va.
Proposed by R. D. Patterson, John Stewart, Thomas H. Clagett.
Born 1871, Rogersville, Ohio. High Schools. Two courses, International Correspondence Schools. 1892–93, Rodman, C. & O. R. R. 1894, 96–97, 99, 1900–01, Full charge, Quinnimont Coal Co. 1895, Constr. Engr., J. M. Clark. 1898, Covington Machine Co. 1902–03, Full charge, War Eagle Coal Co.
Present position—1904 to date: Contracting Civil and Min. Engr.

Henry L. Hamilton, Houston, Tex.
Proposed by W. Lester Walker, Alexander Deussen, G. R. Stevens.
Born 1889, Westley, Cal. 1900–04, Stanford Univ., A. B. 1904–05, Surveyor, Guggenheim Exploration Co. 1905–06, Surveyor, Standard Cons. Min. Co. 1906–07, Engr., Aguascalientes Metals Co., Mexico. 1912–13, Field Engr. 1913–14, Asst. Supt.; 1914–16, Supt., Montebello Oil Co., Cal. 1916–17, Supt., Texas Graphite Co., Texas.
Present position: Geol. and Cons. Engr.

Charles Joseph Hares, Casper, Wyo.
Proposed by W. D. Waltman, Max W. Ball, Chas. T. Lupton.
Born 1881, Marcellus, N. Y. 1907–08, Grad., Univ. of Chicago, B. S. and M. S. 1910–11, Jr. Geol.; 1911–16, Associate Geol.; 1916–17, Paleontologist, U. S. Geological Survey. 1908–10, Held fellowship in geology, Ogden Graduate School of Science, Univ. of Chicago.
Present position: Geol., Ohio Oil Co.

George Julius Horn, Denver, Colo.
Proposed by F. C. Greene, I. F. Laucks, Richard A. Parker.
Born 1886, Denver, Colo. 1905–06, Draftsman, Colorado Telephone Co. 1906–07, Draftsman, Denver Transcontinental R. R. 1907, Draftsman, The Arnold Co. 1907–08, In charge, The Saturday Night Tunnel. 1908, In field, Colorado Southern R. R.; Drill Runner, The Seaman Tunnel. 1908–09, Testing plant, Horn Concentrator. 1909–10, Chief Draftsman, Meeker, Grand Valley & Salt Lake R. R. 1910, In field, Colorado Telephone Co. 1910–11, Transitman, Moffit Railroad Co. 1912, On the road, Hill Publication Co. 1912–16, Mill design, erection, operation, Horn & Horn. 1916–17, Draftsman, Western Chemical Co. 1917, Mill design, erection, operation, Horn & Horn. 1917–18, In charge, Idaho Bride mine; Horn & Horn; Beacon Coal Mines Co.
Present position: Draftsman, Horn & Horn.

Walter A. Janssen, Montreal, Que., Canada.
Proposed by W. M. Corse, William A. Cowan, Stanley G. Flagg, Jr.
Born 1884, Davenport, Ia. 1891, Grade Schools, Davenport, Ia. 1893–1902, Grammar and High Schools, Freeport, Ill. 1907, B. S.; 1914, Ch. E., Univ. of Wisconsin. 1907–09, Draftsman; 1909–10, Chem; 1910–11, Supt., Bittendorf Co. Davenport, Ia. 1911–12, Supt., Davenport, Ia. 1913–17, Supt. of Steel Foundry, Construction Belt Co.
Present position—1917 to date: Operating Mgr., Canadian Steel Foundries, Ltd.

Reuben L. Lindstrom, Montreal, Que., Canada.
Proposed by Fred L. Wolf, W. M. Corse, W. H. Bassett.
Born 1889, Moline, Ill. 1911, Grad., School of Pharmacy, Univ. of Illinois, Ph. G. 1910, Registered pharmacist, State of Ill. 1903–11, Held various positions as pharmacist. 1911–15, Asst. Chief Chem., Deere & Co., Moline, Ill. 1915–17, Chief Chem. and Met., Bittendorf Co., Bittendorf, Iowa.
Present position—1917 to date: Met., Canadian Steel Foundries & Canadian Car & Fdry. Co.

Jean McCallum, Denver, Colo.
Proposed by H. C. Smith, Thomas C. Baker, W. E. Crawford.
Born 1884, Huron, S. D. 1906, High School, Denver, Colo. 1910, Colorado School of Mines, E. M. and E. Met. 1906, Summer, Mucker, Barstow Min. Co., Ouray, Colo. 1908, Summer, Mucker, Trammer and Miner, Liberty Bell mine, Telluride, Colo. 1910, Miner, Machineman, Timberman, Yak M. M. & T. Co., Leadville, Colo. 1911, Millman, Foreman vanner floor, Utah Copper Co., Garfield, Utah. 1911–14, Foreman, classifier, fine-crushing, and concentrating dept., Chino Copper Co., Hurley, N. M. 1914–16, Solution man, Met., Mill Supt., Caribou M. & M. Co., Caribou, Colo. 1916–17, Mill Supt. and Gen'l Supt., Caribou M. & M. Co., Caribou, Colo. 1917–18, Flotation testing work, Cia. Beneficiadora de Pachuca, S. A.
Present position: Asst. Supt., River Smelt. & Refin. Co., Florence, Colo.

Glover S. McKay, San Dimas, Durango, Mexico.
Proposed by Fred B. Goetter, R. H. Townsend, Roy A. Sulliger.
Born 1887, Helena, Mont. 1910, Colorado School of Mines, E. M. 1910–11, Engr., American Smelters Securities Co., Velardena, Mexico. 1911–12, Engr. and Mine Supt., Predilecta Min. Co., Guanacevi, Mexico. 1912, Engr., Cia. Minera Exploradora y Explotadora de Guanacevi, Mexico. 1912–13, Engrg. office, Green River, Utah. 1913–16, Mine Supt.; 1916–17, Asst. Mgr., Mexican Candelaria Co.
Present position—1917 to date: Mgr., Mexican Candelaria Co.

Kirtley F. Mather, Granville, Ohio.
Proposed by David White, F. L. Ransome, George Otis Smith.
Born 1888, Chicago, Ill. Denison Univ., Granville, Ohio. 1909, B. Sc.; 1915, Ph. D., Univ. of Chicago. 1910, Summer, Geologic Aid; 1911, Summer, Junior Geol., U. S. Geol. Survey. 1911–12, Instr. in Geol.; 1912–14, Asst. Prof. of Geol., Univ. of Arkansas. 1913–16, Summers, Junior Geol., U. S. Geol. Survey. 1915–17, Assoc. Prof. of Geol., Queen's Univ., Kingston, Ontario. 1917, Summer, Asst. Geol.; 1918, Summer, Assoc. Geol., U. S. Geol. Survey. 1917–18, Prof. of Paleontology, Queen's Univ.
Present position: Prof. of Geol., Denison Univ.

Chester Sherman Moody, Minneapolis, Minn.
Proposed by Thomas M. Bains, Jr., E. H. Comstocke, William Campbell.
Born 1891, Minneapolis, Minn. 1916, Univ. of Minn., B. Sc.; 1917, Mech. Engr. 1911–17, In varying capacities, Minneapolis Steel & Machinery Co.
Present position—1917 to date: Met. Engr., Minneapolis Steel & Machinery Co.

Hubert E. Nelson, Keokuk, Ia.
Proposed by Thomas F. Wettstein, Austin T. Hyde, James A. Caselton.
Born 1891, Argyle, Ia. 1916, Grad., Univ. of Wisconsin, Ch. E.
Present position—1916 to date: Chem., Technical Dept., River Smelting & Refin. Co.

John Parkinson, London, S. W., England.
Proposed by George A. Macready, John A. Dresser, J. B. Tyrell.
Born 1872, London. 1889, Univ. College, London. 1903, St. John's College, Cambridge, B. A., M. A. 1903–06, Principal Mineral Survey, Sn. Nigeria. 1906–08, Geol., Liberian Dev. Co., Ltd. 1911–13, Water Investigation, Magadi Soda, Ltd., East Africa Protectorate. 1914–15, Water reconnaissance, Government of East Africa Protectorate. Fellow, Geological and Royal Geological Societies of London; M., Inst. M. and M., London.
Present position—1915 to date: Chief Geol., United British West Indies, Pet. Syndicate, Trinidad.

Robert Benson Rogers, Chewelah, Wash.
Proposed by Preston Locke, Bert F. Smith, L. K. Armstrong.
Born 1883, Montclair, N. J. 1905–06, Engr., Hudson Iron Co., Fort Montgomery, N. Y. 1906–07, Scout work, Cobalt and vicinity. 1907–08, Opened assaying and surveying office, patent surveys and U. S. land surveys. 1908–12, Surveyor, Chief Engr., Asst. Supt. of Constr. on new mill and cyanide plant, N. Y. Honduras Rosario Min. Co., Honduras, C. A. 1913–15, Partner, Davis, Rogers Co., Engrs. and Contractors, San Francisco, Cal.; built rock-crushing plant for U. S. Govt., Angel Island; installed steam plant, electric pumping plants and municipal asphalt plant for City of San Francisco. 1916–17, Engr., Ray Cons. Copper Co., Ray, Ariz.
Present position—1917 to date: Supt., Northwest Magnesite Co.

Norman Brownell Roper, Casapalca, Peru.
Proposed by John M. Boutwell, C. V. Drew, J. C. Branner.
Born 1875, Santa Ana, Cal. 1883–92, Public Schools, Santa Ana, Cal. 1892–96, Leland Stanford, Jr., Univ., Mech. E. 1896–99, Machinist, Union Iron Works, San Francisco, Cal. 1899–1900, Draftsman, United Engineering Works, San Francisco. 1900–01, Erecting Engr., Q. M. Dept., U. S. A., Philippines. 1902–06, Draftsman, Supt. of Constr., Cananea Cons. Copper Co., Cananea, Mex. 1906–10, Sales Engr., Power & Min. Machinery Co., New York and Milwaukee. 1910–12, Mech. Supt., Cerro de Pasco Min. Co., La Fundicion, Peru. 1912–17, Supt. of Constr., Smelter Supt., Sociedad Minera Backus y Johnston del Peru.
Present position: Gen'l Mgr., Sociedad Minera Backus y Johnston.

Edward Thomas Rowling, Oruro, Bolivia.
Proposed by H. L. Venables, G. H. Bliek, M. G. F. Sohnlein.
Born 1879, Camborne, England. Public schools; technical training by special study. 1896–98, Dolcoath mine, Cornwall, England. 1901–03, Mill Foreman; 1903–11, Mill Supt., Totoral Min Co. 1911–18, Asst. Mgr., Sociedad Estanifera Totoral Consolidated.
Present position: Gen'l Mgr., La Reina Mine, Sociedad Estanifera Totoral Consolidated.

Edwin Shapley, San Juancito, Honduras.
Proposed by Paul R. Cook, James K. Dickson, Walker B. Longan.
Born 1881, Philadelphia, Pa. Friends Central School, Philadelphia. 1902, Grad. Univ. of Pennsylvania. 1904–07, Surveyor, Assayer, La Luz Min. & Tunnel Co., La Luz, Mexico; Cyanide Shift Boss, Guanajuato Cons. Min. Co.; Refinery Foreman, Peregrina Min. Co., Guanajuato, Mex. 1907–08, Mill Shift Boss, Esperanze Min. Co., El Oro, Mex. 1908–09, Min. Engr., Coahuila Min. & Smelt. Co. 1909–10, Asst. Supt., mine and mill, El Tajo Min. Co., San Sebastian, Mex. 1910–14, Gen'l. Supt., mine, mill and smelter, Cia. Minera Mexicana, Tapalpa, Mex. 1914–15 Mill and cyanide plant, Buckhorn Mines Co., Nev. 1915–16, Construction of mill, Tungsten Mines Co., Bishop, Cal. 1916–17, Sampling, Inspiration Cons. Copper Co., Miami, Ariz.; engineering office for self.
Present position: Mill and cyanide plant, N. Y. & Honduras Rosario Mine.

Edward L. Sweeney, Kennecott, Alaska.
Proposed by Alan M. Bateman, D. D. Irwin, William Douglass.
Born 1888, Cavour, S. D. 1894–1906, Grammar and High Schools. 1910–15, Univ. of Washington, B. S. 1906, Independent Asphalt Paving Co. 1907, Lister Cons. Co., Olympia, Wash. 1907–08, Eng. Dept., City of Tacoma, Wash. 1909–10, Power Plant Construction, Wright & Sweeney, Gen'l Contractors. 1911, Summer, Water Plant, Wright & Sweeney. 1912, Summer, Trip through Southwest min. region. 1913–14, Tacoma Smelt. Co. 1915–16, Assayer, Tacoma Smelt. Co. 1916–18, Assayer, Mill Foreman and Leaching Plant Foreman, Kennecott Copper Corpn.
Present position: Supt., Mill and Ammonia Leaching Plant, same company.

Masayuki Tatsuno, Iyo, Japan.
Proposed by Charles E. Locke, Carle R. Hayward, H. O. Hofman.
Born 1886, Tokyo, Japan. College of Engrg., Tokyo Imperial Univ. 1917–18, Special Student, Mass. Institute ot Technology. 1910–16, Met. Engr., Shisakajima Copper Works, Sumitomo Besshi Mine, Iyo, Japan. 1916–17, Traveling in U. S. and Canada visiting mines and smelters.
Present position: Met. Engr., Sumitomo Besshi Mine, Iyo, Japan.

Douglass Terpstra, Dorchester, Va.
Proposed by J. S. Cheyney, Howard N. Eavenson, E. O'Toole.
Born 1880, The Netherlands. 1902, Grad., Technical School, Univ. of Delft, Mittweida, Germany, E. E. 1902–05, Various phases of electrical work around the world. 1905–08, Installed underground cable system, The Hague, Holland. 1908–13, Constr. Foreman, Easton Penn. Power Co., Easton, Pa. 1913–15, Constr. Engr., New York Min. Mfg. Co.;
Present position—1915 to date: Gen'l Mgr., Wise Coal & Coke Co.

Arthur Clarence Thane, Chewelah, Wash.
Proposed by Preston Locke, Bert F. Smith, L. K. Armstrong.
Born 1886, San Francisco, Cal. 1902–05, School of Mechanical Arts, San Francisco, Cal. 1914–15, Healds Engrg. School. 1913–14, Foreman, Sheepcreek Tunne, Gastineau Min. Co., Juneau, Alaska; Assayer, Surveyor, Eagle River Min. Co., Amalza, Alaska. 1915–16, Millman, Alaska Gastineau Min. Co., Thane, Alaska.
Present position—1917 to date: Mill Foreman, Northwest Magnesite Co.

Associates

Donald Fulton North, Thomas, W. Va.
Proposed by George Morris, Andrew B. Crichton, Boyd Dudly, Jr.
Born 1895, Eleanora, Pa. 1914–17, Pennsylvania State College. 1911–13, Summers, Engr. Dept.; 1913–14, Engrg. Dept., Rochester Pittsburgh Coal & Iron Co., Punxsutawney, Pa.
Present position—1917 to date: Transitman, Engrg. Dept., Davis Coal & Coke Co.

Lynn Leslie Pomeroy, New York, N. Y.
Proposed by R. L. Lloyd, Axel O. Ihlseng, W. E. Pomeroy.
Born 1894, Mesa City, Ariz. 1913–17, Texas School of Mines and Metallurgy. 1906–07, Assayer helper, Greene Gold Silver Co., Ocampo, Mex. 1907–11, School. 1911–12, Feed floor foreman, Shannon Copper Co., Clifton, Ariz. 1912–13, Mine Foreman, W. E. Pomeroy, Alamogordo, N. M. 1913–17, Student, Texas School of Mines and Met. 1917, Smelter Chem., Empire Smelt. Co., Deming, N. M. 1917–18, U. S. Army.
Present position: 1st Lieut., Infantry, U. S. A.

Stanton Umbreit, Milwaukee, Wis.
Proposed by Wells K. Gregg, Richard S. McCaffery, A. N. Winchell, W. J. Mead.
Born 1895, Milwaukee, Wis. 1908–12, East Division High School, Milwaukee. 1912–16, Univ. of Wis., B. S. 1917–18, Grad. Work, Univ. of Wis. 1916–17, Research Chem., Newport Chemical Works, 1917–18, Instructor, Metallography and Pyrometry, Univ. of Wisconsin.
Present position: Research Chem., National Lamp Co.

Junior Associates

James Willes Armstrong, Norman, Okla.
Proposed by C. W. Shannon, George E. Burton, J. M. Herald.
Born 1894, West Plains, Mo.
Present position: Univ. of Oklahoma.

Stephen T. Bergh, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1884, Hillsboro, N. D. 1905–07, Normal School, Moorhead, Minn. 1910–12, Univ. of Wis., Madison, Wis. 1913–14, Treadwell Gold Mines, Alaska. 1915–17, Placer Min., Interior of Alaska.
Present position: Student, Colorado School of Mines.

James R. Dorrance, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1900, Bishop, Cal. 1914–15, Bishop Union High School, Bishop, Cal. 1915–16, Big Pine High School, Big Pine, Cal. 1916–17, California School of Mechanical Arts. 1916, Summer, Los Angeles Aqueduct Co. 1917, Summer, California State Highway Commission. 1918, Summer, Saline Valley Salt Co., Cal.
Present position: Student, Colorado School of Mines.

George Vincent Dunn, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1898, Golden, Colo. 1912–16, Golden High School.
Present position: Student, Colorado School of Mines.

Walter Arthur Emanuel, Madison, Wis.
Proposed by W. J. Mead, A. N. Winchell, Richard S. McCaffery.
Born 1896, Fall Creek, Wis.
Present position: Student, Univ. of Wisconsin.

George M. Enos, Rapid City, S. D.
Proposed by F. W. Traphagen, Charles Bentley, W. C. Bochert.
Born 1896, Dubuque, Iowa. 1912–14, High School, Philips, S. D. 1918, Summer, Constr. work, Western Potash Works, Antioch, Neb.
Present position—1916 to date: Student, Asst. Chem., South Dakota State School of Mines.

Anthony Folger, Berkeley, Cal.
Proposed by G. C. Gester, Frank H. Probert, George D. Louderback.
Born 1896, Portland, Ore. 1915–19, Univ. of California, Senior on leave of absence.
Present position: Geological Dept., Standard Oil Co., San Francisco, Cal.

Paul Artmus Gochenour, Delphi, Ind.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1899, Delphi, Ind. 1914–18, Delphi High School.
Present position: Student, Colorado School of Mines, Golden, Colo.

Ralph Julius Hall, Rapid City, S. D.
Proposed by F. W. Traphagen, Charles Bentley, W. C. Bochert.
Born 1896, Lead, S. D. 1914, Grad., Lead High School. 1914, Min., Homestake Min. Co., Lead, S. D. 1918, Mill and Assayer, Manion Operating Co., Lead, S. D.
Present position: Student, South Dakota State School of Mines.

Thomas B. Leech, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1898, Cripple Creek, Colo. 1916, Grad., Central High School, Muskogee. 1916, Western Spelter Co., Henryetta, Okla. 1917, Traveling Inspector and Laboratory Inspector, The Texas Co., Tulsa, Okla.
Present position: Student, Colorado School of Mines.

Frederick A. Lichtenheld, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1896, Central City, Colo.
Present position: Student, Colorado School of Mines.

Otto H. Metzger, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1894, Meeker, Colo. 1910–14, Rio Blanco High School. 1914–15, Univ. of California. 1916, Summer, Trammer, Golden Cycle Min. Co., Cripple Creek, Colo. 1917, Summer, Sampler, Alto Min. Co., Telluride, Colo.
Present position: Student, Colorado School of Mines.

Ernesto Ornelos, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1891, San Pedro, Coah., Mex. 1906–11, Preparatory School, Cascadilla School, Ithaca, N. Y. 1911–15, Sibley College, Cornell Univ., Ithaca, N. Y., M. E. 1915–17, Remington Arms, U. M. C. Co., Bridgeport, Conn. 1917–18, Bridgeport Brass Co., Bridgeport, Conn.
Present position: Student, Colorado School of Mines.

Otto Adolph Ray, Madison, Wis.
Proposed by Richard S. McCaffery, W. J. Mead, A. N. Winchell.
Born 1895, Fish Creek, Wis.
Present position: Student, Univ. of Wisconsin.

Lloyd Milton Scofield, Sturgeon Bay, Wis.
Proposed by Richard S. McCaffery, W. J. Mead, A. N. Winchell.
Born 1897, Sturgeon Bay, Wis.
Present position: Student, Univ. of Wisconsin.

Hugh Martin Shepard, Hamilton, Ont., Canada.
Proposed by George A. Guess, H. E. T. Haultain, Frederick C. Dyers.
Born 1899, Hamilton, Ont., Canada. 1912–17, Hamilton Collegiate Institute, Hamilton, Ont., Canada. 1917–18, Faculty of Applied Science, Univ. of Toronto. 1917, Summer, Hamilton Facing Mills, Hamilton, Ont., Canada. 1918, Summer, Dominion Steel Foundry Co., Hamilton; Blast Furnace Steel Co. of Canada.
Present position: Student, Univ. of Toronto.

Wilbur Augustus Treadwell, Jr., Pueblo, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1899, Victor, Colo. 1913–18, Central High School, Pueblo, Colo. 1915, Locomotive Craneman, Colorado Fuel & Iron Co., Pueblo, Colo. 1918, Chem., Norcross Chemical Co., Denver, Colo.
Present position: Student, Colorado School of Mines, Golden, Colo.

William Albert Waldschmidt, Rapid City, S. D.
Proposed by F. W. Traphagen, Charles Bentley, W. C. Bochert.
Born 1897, Riverton, Neb. 1916, Grad., High School, Lead, S. D. 1913, 14, 15, Summers, Min., Homestake Min. Co. 1916, Summer, Mill., Elk Mt. Min. & Mill. Co., Deadwood, S. D. 1918, Surveying, Warren-Lamb Lumber Co., Rapid City, S. D.
Present position: Student, South Dakota School of Mines.

Warren Weir Walters, Madison, Wis.
Proposed by Richard S. McCaffery, W. J. Mead, A. N. Winchell.
Born 1898, Orland, Cook Co., Ill. 1912–16, Crane Tech. H. S., Chicago. 1916, Univ. of Wis. 1918, Summer, Mine Surveyor, M. A. Vlamia Ore Min. Co., Virginia, Minn.
Present position: Student, Univ. of Wisconsin.

Edward O. Werba, Madison, Wis.
Proposed by Richard S. McCaffery, W. J. Mead, A. N. Winchell.
Born 1897, Milwaukee, Wis. 1916, Miner, Martin mine, Benton, Wis. 1917, Draftsman, Cutter Hammer, Milwaukee, Wis. 1918, Min. Eng., Mine Carlota, Cuba.
Present position—1915 to date: Student in Min., Univ. of Wisconsin.

Yu Den Woo, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1898, China. 1917–18, Student in Min., Univ. of California.
Present position: Student, Colorado School of Mines.

Change of Status—Junior Associate to Member

John M. Price, Fort Sill, Okla.
Proposed by J. Burns Read, Charles H. Fulton, Zay Jeffries.
Born 1889, Ironton, Ohio. 1898–1903, Common School. 1903–07, Ironton High School. 1907–10, Western Reserve Univ. 1911–13, Case School of Applied Science. 1913–16, Chief Engr.; 1916–18, Asst. Supt., Ottawa mine, Montreal Min. Co., Hurley, Wis.
Present position: 2d Lieut., Air Service, Military Aeronautics.

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Meets second Tuesday of each month.

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[1] Until Feb., 1919. [2] Until Feb., 1920. [3] Until Feb., 1921. [4] Until Feb., 1922.

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(Give name in full: initials not sufficient.)

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If you wish the Institute to secure the necessary signatures please give below the names of at least five members or associates with whom you are acquainted. A list of members will be sent on application.

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m	To		Total Time	In Responsible Charge	

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Extract From Constitution

ARTICLE II

Members

SEC. 1. The membership of the Institute shall comprise four classes, namely: 1. Members; 2. Honorary Members; 3. Associates; 4. Junior Associates.

All members shall be equally entitled to the privileges of membership, excepting that Honorary Members, Junior Associates, and Members and Associates whose residences shall be outside of the United States, Mexico, and Canada, shall not be entitled to vote. Members and Associates residing within the United States of America, Mexico, and Canada, and not in arrears for dues, shall be entitled to vote in person at the meetings of the Institute, or, as hereinafter provided for, by letter ballot.

SEC. 2. MEMBERS shall comprise all those persons who on the third Monday of February, 1918, were members of the Institute, and in addition thereto, all those thereafter elected or transferred into the class of Members.

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Graduation from the scientific course of a college, approved by the Committee on Membership, shall be considered equivalent to two years' employment, as required in the previous sentence.

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Persons employed in research or any scientific literary work or in teaching in the scientific departments of colleges, approved by the Committee on Membership, who at the same time are engaged in consulting or in the active practice of mining, geology, or metallurgy, shall be entitled to consider the time so spent in active practice as equivalent to an equal length of time of employment in positions of responsibility, provided the work done or the positions held seem to the Committee on Membership to warrant the equivalency.

The requirement of three years' employment in positions of responsibility may be waived by the Committee on Membership in the case of persons who have done notable original work in mining, geology, or metallurgy, or have won distinction by research or investigations in one or more of these subjects. By investigation or research is understood laboratory experimentation as distinct from investigations in literature or compilations of the work of others.

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JUNIOR ASSOCIATES shall comprise all students in good standing in engineering schools, who have not taken their degrees and are nominated by at least three members, two of whom must be their instructors. A Junior Associate may remain such not longer than five years after leaving the engineering school, at the end of which period his qualifications to become a Member or Associate must be passed upon by the Committee on Membership. If elected he shall pay at that time the entrance fee and dues of a Member or Associate.

In case there is any question as to the classification of a candidate the Committee on Membership may require from him any evidence he desires to present and the decision of the Committee as to the proper status shall be final.

Every candidate for election as a Member, Associate, or Junior Associate must be proposed for election by at least three Members or Associates, must be approved by the Committee on Membership, as prescribed in the By-Laws, and must be elected by the Board of Directors

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York Meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Petroleum Hydrology Applied to Mid-Continent Field*

BY ROY O. NEAL,† BARTLESVILLE, OKLA.

(New York Meeting, February, 1919)

THERE are two main sources of the water that floods productive oil or gas sands. The water may rise from the lower depths of the producing stratum, or it may come from beds above or below the oil-bearing formation. Usually the recovery of oil is decreased by water entering the oil sands, and most oil-field waters, especially those of deep wells, tend to foster the formation of an emulsion, which is expensive to treat. This paper deals with a method of distinguishing between waters that encroach upon oil-bearing beds from sources in the same stratum and waters that reach the oil sands from horizons above.

In order to remedy effectually water difficulties in oil and gas wells, it is absolutely necessary to determine the source of the invading water. Sometimes evidence such as the structural relations between the strata penetrated by neighboring wells and those found in the well under investigation is not adequate; also, data from drill logs and well records, from mechanical tests made on the wells by plugs, testers, drilling tools, etc., and from tests by chemical indicators such as eosin and Venetian red, may be unsatisfactory, for such data may fail to locate the source of the infiltrating waters. As a resort in such cases, the application of chemical analyses, that is, the comparison of an analysis of the water in question with that of typical waters from the various water horizons in that particular district, has in certain instances proved of value. This method has been used to advantage in the Westside Coalinga field of California, where the source of water may be fairly definitely determined from its composition.

The chief conclusions concerning the chemistry of the oil-field waters in California by G. S. Rogers[1] are: "Oil-field water is not necessarily salty, as is generally believed, and may not be even slightly salty to the taste. The degree of concentration of chloride in such water is governed primarily by local conditions and is not affected by the position

* Published by permission of the Director of the U. S. Bureau of Mines and of the Empire Gas & Fuel Co. The data for this article were obtained by the writer in an investigation for the benefit of the sub-surface division of the Geological Department of the Empire Gas & Fuel Co. while he was chemist for this company.

† Petroleum Experimental Station, U. S. Bureau of Mines.

[1] Chemical Relations of Oil-field Waters in San Joaquin Valley, California. U. S. Geol. Sur. *Bull.* 653 (1917), 6.

of the water in relation to oil. Sulfate diminishes in amount as the oil zone is approached and finally disappears. The concentration of carbonate increases as the oil zone is approached, but depends largely on the concentration of chloride. The horizon, with respect to the oil zone, at which these alterations take place, is different in each field."

The conditions existing in the Mid-continent field are very different from those in California; in fact, each pool probably has its own peculiarities, wholly different from those of any other district. In all pools in the Mid-continent fields that have come to the writer's attention, the sulfates increase as the oil horizon is approached. In fact, in most cases the sulfate content of top waters is practically nil whereas in the bottom

TABLE 1.—*Analyses of Bottom Water Below 2500-ft. Sand in Augusta Field*

	Average of Twenty Samples Distributed Over Field	Northern Extremity of Field	Southern Extremity of Field	Center of Field, Depth 2545 Ft.
Primary salinity, per cent......	79.18	77.30	80.03	79.10
Secondary salinity, per cent....	19.98	21.82	18.66	19.19
Secondary alkalinity, per cent.	0.84	0.89	1.32	1.71
Chloride salinity, per cent.....	92.08	88.68	90.88	91.84
Sulfate salinity, per cent......	7.08	10.43	7.73	7.27
Iron, parts per million........	22	32	38	56
Calcium, parts per million.....	1,779	1,987	1,580	1,808
Magnesium, parts per million..	464	445	544	455
Sodium and potassium, parts per million....................	11,146	10,879	11,592	11,317
Bicarbonate, parts per million.	313	234	353	456
Sulfate, parts per million......	2,086	2,635	1,986	1,893
Chloride, parts per million.....	20,007	19,552	20,384	20,384
Total solids, parts per million	35,817	35,764	36,477	36,369

waters the sulfate salinity has reached as much as 10.5 per cent. The sulfate content has proved a trustworthy indication of bottom waters, which is contrary to the results obtained by Rogers for the California fields. The bicarbonates vary irregularly and are not consistent, none of the waters examined showing more than a trace of carbonates. The total solids of the bottom waters always was considerably lower than that of any of the top waters, and is a fairly reliable property to study in differentiating between top and bottom waters. More recently the method has been used extensively by the Empire Gas & Fuel Co. in the Butler County fields of Kansas and to a slight extent in the Blackwell field of Oklahoma.

In Table 1 are the analyses of bottom waters of the Augusta field.

The primary salinity[2] is due to the presence of alkaline salts of the strong acids; secondary salinity is due to the presence of calcium and magnesium salts of the strong acids. Secondary alkalinity is due to the presence of the salts of magnesium, calcium, and iron of weak acids. Chloride salinity is equal to the sum of the combined chlorides present and sulfate salinity is equal to the sum of the combined sulfates. The uniformity of the various bottom waters is conspicuously apparent from these data. From the results of more than 125 samples in the Augusta field, it was found that the sulfate varied from 7.15 per cent. to 10.52 per cent.; the chloride salinity ranges from 88.44 per cent. to 94.25 per cent. of all the properties, with practically all the results below 92 per cent.; and the primary salinity between 70.72 per cent. and 85.55 per cent. of all the properties.

In Table 2 are given the analyses of top waters, above the 2500-ft. sand, from distinctly different water horizons in the Augusta field. The primary salinity of some 50 samples of top waters varied from 70.72 per cent. to 85.55 per cent. of the total properties; the secondary salinity from 14.12 per cent. to 29.25 per cent.; the chloride salinity from 87.90 per cent. to 99.98 per cent.; and the sulfate salinity from a trace to 0.35 per cent.

TABLE 2.—*Analyses of Waters Above 2500-ft. Sands in Augusta Field*

	From 2160-ft. Water Sand	From 1280-ft. Water Sand	From 1660-ft. Water Sand
Primary salinity, per cent	80.24	80.92	74.41
Secondary salinity, per cent	19.74	19.02	25.55
Secondary alkalinity, per cent	0.02	0.06	0.04
Chloride salinity, per cent	99.62	99.94	99.96
Sulfate salinity, per cent	0.35	none	none
Iron, parts per million	117	48	52
Calcium, parts per million	4,950	6,710	7,440
Magnesium, parts per million	1,915	2,762	2,960
Sodium and potassium, parts per million	34,452	49,298	37,026
Bicarbonate, parts per million	10	68	41
Sulfate, parts per million	252	trace	trace
Chloride, parts per million	67,300	95,800	78,800
Total solids, parts per million	108,996	154,686	126,319

The chief distinction between the top and bottom waters is the percentage of total solids. The content of solids in the top waters averages

[2] Chase Palmer: Geochemical Interpretation of Water Analyses. U. S. Geol. Sur. *Bull.* 479 (1911).

four or five times as great as that of the bottom waters. The difference in the chloride salinity between top and bottom waters is a reliable index to use in differentiating the various waters. The distinctive character of the waters as regards the sulfate content can be used in classifying top and bottom waters.

From these data, it is obvious that the top and bottom waters are distinctly and uniformly unlike and that it is an easy matter to differentiate them; it is extremely difficult, however, to distinguish between the various top waters, inasmuch as there appears to be no uniformity in their composition. The top and bottom waters being so different in total solids, and hence in specific gravities, it has been suggested[3] that a

TABLE 3.—*Analyses of Water in Augusta Field*

No.	Lease and Well No.	Section	Total Solids	Chlorides	Sulfates
1	Love No. 15	29	49,932	29,120	2,424
2	Love No. 6	29	40,860	23,296	2,860
3	Love No. 7	20	41,028	23,296	2,992
4	Long No. 2	8	43,500	24,960	2,096
5	E. Varner No. 9	17	46,732	25,792	2,700
6	E. Varner No. 7	17	49,008	24,544	2,424
7	Smith No. 11	20	46,620	26,208	2,396
8	Smith No. 14	17	41,200	22,464	2,644
9	Haskins No. 8	17	153,600	94,640	892
10	Miller No. 6	2	34,032	19,136	2,644
11	Martin No. 5	2	40,300	24,960	2,516
12	F. Varner	16	36,336	20,592	2,560
13	E. Varner No. 9	16	42,528	22,464	2,940
14	F. Varner No. 16	16	155,956	97,760	696
15	Ralston No. 25	9	35,588	22,464	2,328
16	Scully No. 4	9	33,320	18,720	2,444
17	F. Varner No. 12	16	37,428	21,636	2,748
18	Ralston No. 18	8	41,872	24,544	2,588
19	Scully No. 10	9	39,152	22,464	2,876
20	Curry No. 2	16	37,428	25,584	2,404
21	Ralston No. 6	9	41,756	24,028	2,752
22	F. Varner No. 12	16	47,496	26,208	2,920
23	F. Varner No. 1	16	36,148	21,216	2,860
24	Ralston No. 5	17	43,808	25,792	2,896
25	Curry No. 1	16	36,000	22,048	2,484
26	Feltham No. 15	10	43,128	24,960	1,512
27	Brown No. 10	16	39,656	22,880	2,952
28	Ralston No. 9	9	38,736	22,048	2,840
29	Curry No. 3	16	90,684	58,240	1,864
30	Feltham No. 13	10	37,364	21,632	2,436
31	E. Varner No. 6	16	38,320	20,592	2,588
32	Cunningham No. 4	16	36,116	20,592	2,416

[3] J. O. Lewis, Petroleum Technologist, U. S. Bureau of Mines, in interview.

hydrometer be used to distinguish the waters. In most cases only three determinations—namely, total solids, sulfates, and chlorides—are necessary to detect mixed or top water that has infiltrated into the oil sand, as is shown by Table 3. It is apparent that samples Nos. 9, 14,

TABLE 4.—*Properties of Water in El Dorado Field*

	Bottom Water From 2450-ft. Sand, Per Cent.	Top Water From 1500-ft. Horizon, Per Cent.
Primary salinity	80.20	81.32
Secondary salinity	17.90	18.66
Secondary alkalinity	1.90	0.02
Chloride salinity	92.72	99.80
Sulfate salinity	5.38	0.18

and 29 are top waters or of a mixed type. Complete analyses are recommended when interpreting results of a questionable mixed water. There is a close agreement among the various bottom waters, the results from the various leases in the field nearly coincide. The analyses of

TABLE 5.—*Analyses of Water in El Dorado Field*

	Composition, in Parts per Million		Reacting Values, in Per Cent.	
	Bottom Water From 2450-ft. Sand	Top Water From 1500-ft. Horizon	Bottom Water From 2450-ft. Sand	Top Water From 1500-ft. Horizon
Iron	42	63	0.15	0.04
Calcium	1,350	5,663	6.68	5.02
Magnesium	377	2,935	3.07	4.28
Sodium and potassium	9,318	52,652	40.10	40.66
Bicarbonate	587	40	0.95	0.01
Sulfate	1,310	236	2.69	0.09
Chloride	16,640	99,640	46.36	49.90
Total solids	29,624	161,229		

the top waters, even from the same horizon, do not correspond even to a degree whereby they can be specifically identified.

Practically identical results were obtained in the El Dorado field, the analyses of the water being very similar to those of Augusta, the only difference being in the smaller content of total solids in bottom waters as is shown by Tables 4 and 5.

The following reaction coefficients were used in calculating the reactive values of the various constituents in these waters:[4]

Calcium	0.0499	Sodium	0.0435	Bicarbonates	0.0164
Magnesium	0.0822	Potassium	0.0256	Sulfates	0.0208
Iron	0.0358	Carbonates	0.0333	Chlorides	0.0282
Aluminum	0.1107				

Analyses of the waters from the typical water horizons in the Blackwell (Oklahoma) field are relatively similar to those of the Kansas field, excepting that the concentration of the various salts is somewhat higher. The analyses are given in Table 6.

TABLE 6.—*Analyses of Water in Blackwell Field*[5]

	Water From Depth of 2226-ft.	Water From Depth of 2640-ft.	Water From Depth of 3412-ft.
Primary salinity, per cent	87.97	93.06	78.24
Secondary salinity, per cent	12.02	6.93	21.71
Secondary alkalinity, per cent	0.01	0.01	0.05
Chloride salinity, per cent	99.99	99.99	99.59
Sulfate salinity, per cent	None	None	0.36
Iron, parts per million	52	185	174
Calcium, parts per million	5,950	3,412	2,407
Magnesium, parts per million	3,855	2,470	9,353
Sodium and potassium, parts per million	91,276	104,079	62,089
Bicarbonate, parts per million	25	21	58
Sulfate, parts per million	None	None	475
Chlorides, parts per million	162,240	173,680	126,800
Total solids, parts per million	263,398	283,847	201,356

The general definition of a connate water is, according to Rogers:[6] "A sample of salt water may reasonably be called connate if it approximates ocean water in chemical composition and if it occurs in rocks of marine origin in which the circulation of the water is very slight. For practical purposes, therefore, connate water may be defined simply as fossil sea water." Although it could not be expected that fossil sea water would remain unchanged in its original chemical constitution when in contact with various rocks, it is remarkably striking how closely the composition of Augusta bottom water resembles that of ocean water. This is shown by the analyses given in Tables 7 and 8.

[4] Taken from Kansas State Board of Health Reports.

[5] Oil strata are at 1700 ft. and 3400 ft. (518 m. and 1036 m.).

[6] *Op. cit.*, 22.

Paramount in importance is the collection of representative samples of waters from the various water horizons and from wells distributed over the entire field. Reliable samples can be taken only at the time of drilling into water strata and it may prove profitable, especially in a newly developed field, to collect representative samples, label carefully while drilling the well, and preserve for future reference in case water troubles arise later. After an adequate number of trustworthy samples of typical waters have been examined, it is possible to form an estimate on the probable location of the water in question after comparing with analyses of water from known horizons. It might be emphasized that too much care cannot be exercised in procuring representative samples, also that generalizations should not be drawn from a few specific cases—that is, too few analyses.

TABLE 7.—*Properties of Sea Water and Augusta Bottom Water*

	Augusta Bottom Water,[7] Per Cent.	Sea Water,[8] Per Cent.
Primary salinity	79.18	78.60
Secondary salinity	19.98	21.10
Secondary alkalinity	0.84	0.30
Chloride salinity	92.08	90.30
Sulfate salinity	7.08	9.24

TABLE 8.—*Comparison of Sea Water and Augusta Bottom Water*

	Composition, in Parts per Million		Reacting Values, in Per Cent.	
	Augusta Bottom Water[7]	Sea Water[8]	Augusta Bottom Water[7]	Sea Water[8]
Sodium and potassium	11,146	11,100	39.59	39.31
Calcium	1,779	420	7.23	1.77
Magnesium	464	1,300	3.12	8.92
Iron	22	.....	0.06	
Sulfates	2,086	2,700	3.54	4.62
Chlorides and bromide	20,007	19,410	46.04	45.22
Bicarbonates	313	.....	0.42	
Carbonates	.....	.....	.....	0.16
Total solids	35,817	35,000		

It would be a matter of speculation to say that the application of chemistry to water problems in other Mid-continent fields would be

[7] Average of 20 analyses of Augusta bottom water.

[8] Mean of 77 analyses of sea water, by W. Dittman, given by Chase Palmer in U. S. Geol. Sur. *Bull.* 479.

as beneficial as they have been in Butler County, but inasmuch as good results have been obtained in all the pools that have been examined, namely, El Dorado, Augusta, and Blackwell, as well as the California fields, it seems possible that the principle can be practically demonstrated in other fields, although the characteristics of the water in each pool will be distinctive. This method is not recommended as foolproof or as a panacea, but should not be neglected in determining the source of waters intruding upon oil-bearing formation, because it has been so successfully applied in the Butler County fields and will undoubtedly prove of much value in other fields, especially where complicated water difficulties are encountered.

The writer wishes to express his appreciation of the assistance and coöperation rendered by A. J. Diescher, A. W. McCoy, L. E. Jackson, and W. A. Williams of the Empire Gas & Fuel Co., J. O. Lewis of the Bureau of Mines, and Dr. Chase Palmer and Dr. G. Sherburne Rogers of the U. S. Geological Survey.

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Mining Methods of United Verde Extension Mining Co.

BY CHARLES A. MITKE,* A. B., PH. B., BISBEE, ARIZ.

(New York Meeting, February, 1919)

The United Verde Extension mine is located in the Jerome mining district, on the eastern slope of the Black Hills, approximately northeast of the town of Jerome, Yavapai County, Arizona. The ore deposit may be termed a replacement in Yavapai schist. This schist is one of the oldest formations in the district, being probably of volcanic origin, and has been folded and faulted and contains intrusions of diorite and quartz porphyry. It is believed that the mineralization followed the porphyry intrusions and replaced the country rock; this was followed by erosion and a period of secondary enrichment, all completed in pre-Cambrian time. Later sediments of sandstones and limestones, to the depth of approximately 600 ft. (182 m.), were laid down, followed by volcanic flows. Faulting and erosion again took place, resulting in the present complicated arrangement of the strata. Prospecting, therefore, is very difficult, because the sediments practically cover the mineralized areas. This necessitates the sinking of deep shafts, cross-cutting, and, in some instances, diamond drilling to learn something of the various relations of the different formations and the occurrences of intrusions associated with ore deposition. The locating of new orebodies, therefore, is beset with innumerable difficulties.

Early Mining Methods

The two orebodies constituting the principal resources of the company are known as the small orebody and the Bonanza, or large orebody. These are about 150 ft. (45 m.) apart, and while they appear to be distinct orebodies may later prove to be connected. The character of the ore, the general associations of the porphyries adjoining the orebodies, and other characteristics, both in the ore and general environment, are very similar. The small orebody was the first to be discovered and was mined for some time before the Bonanza was found.

At first, a large amount of ore was extracted by means of development

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work, but as the smelters treating this class of ore were located from 60 to 400 mi. (96 to 643 km.) away, only the highest grade yielded a fair profit and it became necessary to do selective mining. The main workings of the mine were on the 1300-ft. (396-m.) and 1400-ft. (426-m.) levels. Square-set stopes were located on these levels in the high-grade ore in approximately the center of the orebodies; and at this time only the very richest ore (averaging 20 to 50 per cent. carload lots) was taken. This ore was hoisted up the Edith shaft, transported over the aerial tramway to loading bins on the Verde Tunnel & Smelter Railway, where it was loaded into cars and shipped to the smelters. During the 2½ years it was necessary to continue selective mining, the company's smelter in the Verde Valley, some 5 mi. away, was being designed and constructed; a new main hoisting shaft was put down and concreted; and a haulage tunnel driven, connecting directly with the company's railroad to the smelter. The average monthly production during this period was about 4,000,000 lb. (1,814,360 kg.) copper.

On July 18, 1918, the blast furnace was put in operation and the reverberatory was completed on Oct. 2. Owing to the difficulty experienced in obtaining cars, all ore shipments to distant smelters were discontinued when the first unit was put in operation, so that the monthly production dropped somewhat, due to the temporary limited capacity of the smelter. Now that both units are completed, it is expected, unless labor difficulties interfere, that normal production will be continued.

Prior to the blowing in of the smelter, a definite plan was carefully worked out for mining according to a regular system, and for stoping the ore as it exists in place, without regard to grade, but with emphasis on complete recovery as far as possible, on account of the general high copper content, and with special reference to fire protection. No plan for stoping an orebody is complete which does not include provision for adequate ventilation in all the working places nor protection from fire from either natural or artificial causes. Therefore, in planning a stoping method for the average grade of ore and to open up sufficient stopes to furnish a daily tonnage that would ultimately amount to the capacity of the smelter, selective mining had to be abandoned and a number of considerations taken into account.

Considerations Influencing Choice of Mining Methods

It was of prime importance that the method selected rank high among the most approved safety-first methods. The character of the ore made it necessary that the stoping method permit of maximum ventilation in order to provide satisfactory working conditions. It was important that the efficiency be unimpaired when changing from selective mining to a system for mining the average grade of ore. The

ore contains approximately 25 per cent. sulfur; therefore there is extreme danger from fire. One fire has occurred in the small orebody, due to friction caused by caving ore and pyrite. The mining method should not leave pillars, as these are likely to be crushed and generate heat. The ore is very rich, so that a high extraction was necessary; consequently, a low mining cost per ton was of secondary importance. Small bodies of high-grade silver ore occur in the capping, which it is most desirable to recover. Intermediate drifts from the stopes into the walls have encountered scattered bodies of rich copper ore, containing a high percentage of sulfur; provision had to be made for the recovery of this ore. The ore is very heavy; the accepted figure for ore in place is approximately 9 cu. ft. (0.25 cu. m.) per ton. It has the same cleavage as the schist it replaced; it has therefore many seams and caves readily when not supported, especially at the junction of the ore and capping, 60 ft. (18 m.) above the 1300-ft. level, where the ore simply falls, leaving the capping suspended.

Owing to the unusual size and shape of the Bonanza orebody, methods containing stopes extending vertically rather than horizontally could be used to advantage. In some places the capping is quite soft and would cave if not supported. Practically the whole capping above the Bonanza is a mass of silica. As siliceous material is necessary for smelting purposes, certain silica stopes must be operated from time to time. The walls surrounding the orebodies are, in many places, composed of altered quartz porphyry, which is very soft, and, as a consequence, the stopes near them were very heavy.

Mining Methods Suggested

Caving System

The ordinary block caving systems were at once ruled out, for while the cost of mining is low, the great friction that results from caving an orebody containing a high percentage of sulfur invariably results in a mine fire; the stopes would also be so hot as to be unworkable. A large proportion of the ore would become diluted with waste, while some of it would actually be lost. The small bodies of silver ore in the capping would suffer considerable dilution and probably be lost. The scattered bodies of copper ore occurring in the walls surrounding the orebody would cave with the capping, as the walls in places are decomposed quartz porphyry, which is very soft and would readily follow a general cave.

Shrinkage Method

In drawing off a stope of this character, the ore would become very hot; this is shown by the heat generated when a chute full of ore is emptied. The greatest difficulty would be experienced in drawing the

pillars, as these would generate sufficient heat to cause fire. The ore drops off in large blocks, which would make it extremely dangerous for miners to attempt drilling in shrinkage stopes. No stope, from which a permanent supply of silica might be obtained, could be located in the capping, as this would all be caved within a short time.

Top-slice Methods

Neither horizontal nor incline top-slicing were considered applicable to either the small or large orebody, for the following reasons:

1. Fire from natural causes. Small bodies of pyrite have been located above the Bonanza, and there is a possibility of other bodies of pyrite existing around the edges of this ore. Bodies of high-grade copper with high sulfur content have also been found around its sides. If, therefore, the capping and the walls around the orebody, which are very soft, cave, some of the pyrite and high-sulfur ore will come in contact with the timbered mat, and ultimately result in a mine fire.

Bodies of pyrite in the soft hanging wall of the small orebody would cave upon the timbered mat if top-slicing were used. In the early part of 1917, a cave occurred in this orebody, causing considerable friction and heating the ore until the sulfur took fire. The entire stope had to be put under pressure before mining operations could be resumed.

2. Fire from incendiarism. Top-slicing lends itself more readily to this danger than any other method of mining. Numerous fires in top-slice stopes in this State during the past 2 yr. have originated from this cause. These mine fires are very dangerous, expensive, and difficult to get under control. They cannot be sealed off from the rest of the mine, as the ground above is caved and gases may pass through these caves into the live workings. These fires are hard to handle and generally require a temporary shutdown of that particular orebody. During the past year, a large orebody mined by this method was closed for 5 mo. because of an incendiary fire.

3. In every top-slice stope, a small percentage of ore is lost in the mat. As the mat becomes thicker and the weight from above increases, this ore, which is held in the timbered mat under great pressure, will generate heat because of its high percentage of sulfur and will develop into a mine fire.

4. In case of fire in the timbered mat, it would be necessary to drive drifts and raises above the mat in order to turn water on the fire. This would be extremely dangerous, as it would require spiling through caved ground, with the probability of having the working drifts closed by movements in the extensive cave.

5. In the majority of cases, in top-slicing high-grade copper ore in deep mines in Arizona, where there is at least 1000 ft. (304 m.) of overbur-

den, an excessive amount of timber must be used in order to make the recovery of ore as great as possible. This adds considerably to the mining cost.

6. Where top-slicing is used in deep mines in the Southwest, the overburden, as a rule, does not follow readily. Consequently, after the top-slice has been carried down several floors and a large area opened up, huge boulders, perhaps hundreds of tons in weight, are likely to drop from the back and close up the top-slice. In one mine containing a stope of this character, 1200 ft. (365 m.) underground, the crash came unexpectedly and closed up the slice. Providentially, this occurred on change day when the mine was idle.

7. Top-slices in deep mines are more difficult to ventilate than other stopes, because there is no connection from the stoping level to the level above, whereas when they are located near the surface the ground is so thoroughly broken that the warm air from the slice can escape through the capping.

8. Top-slicing is not as flexible a method as square-setting, as it does not permit the mining of disconnected stopes in different parts of the ore-body in order to obtain the necessary daily quantities of proper fluxing material for the smelter, such as iron, silica, etc. In top-slicing, mining would necessarily be commenced on parallel horizons at the top of the ore-body and the secondary, or high-grade, ore would be exhausted before the primary, or low-grade, ore could be stoped. Under these circumstances, a constant production could not be maintained throughout the life of the mine.

Cut-and-fill Method

Examples of caves in large square-set stopes in this mine have shown that the ore does not support itself as it would have to do in a cut-and-fill stope. Furthermore, even if cut-and-fill stopes could be carried up on the 1400-ft. (426 m.) level, they would have to be carried up under old square-set stopes that are filled with waste and would later have to be changed over to square-setting. In every instance, it has been found difficult to make the connection at the 1300-ft. level on account of the heavy overburden. Therefore, if cut-and-fill stopes should be put in they would have to be taken up extremely narrow, lagging put in very close, and preferably double-lagged on the sides to prevent loss of ore. Lagging would also have to be put in the back, which is not practical in a cut-and-fill stope and, eventually, these would have to be changed over to square sets, in order to make connection with the filled stopes on the 1300-ft. level. Under these circumstances, the amount of timber required in the extremely small and narrow cut-and fill stopes, with cribs to support the back, would be equal to that used in square-setting.

Square-setting

The first method employed was the square set. In the beginning, before much was known regarding the nature of the ore, these stopes were taken up large and some caves resulted. Experimentation showed that a better way was by narrow sections of square-set stopes, about two sets in width and taken any convenient length. This proved entirely satisfactory as regards mining and costs, the only objection that might be raised being that a direct timber connection would exist between all the old and new square-set stopes. Should fire occur in any part of the large orebody, it might spread to the old and new square-set sections.

Mitchell Stoping Method

In order to eliminate the foregoing objection and to introduce a more fire-proof method of mining, in the early part of 1917, the writer recommended the use of the Mitchell stoping method. One of these stopes was immediately started on the 1300-ft. level, which proved very successful from a mining point of view and also from the standpoint of costs, as the expense was even less than that of square-setting. It was also very satisfactory as regards fire protection, inasmuch as in mining by this system large barriers of waste, which act as fire breaks, were left between the square-set sections.

In some camps this mining method is known as the "Mitchell slice." Under this name, however, it has frequently been confused with top-slicing, which is a caving method, whereas the Mitchell system is really a combination of square-setting, mining pillars, and filling with waste, thus keeping the overburden intact. Therefore, in order to avoid any misunderstanding, it is referred to in this paper as the "Mitchell stoping method."

Square-set and Pillar Method

It was suggested to mine the orebody by this method, which consists of alternate rows of square sets and pillars through the entire orebody, the rows of square sets to be from three to ten sets wide, according to the weight of the ground, and the pillars between the rows 12½ ft. (3.8 m.) in width.

After the square-set stopes were carried up, the pillars were to be mined by the overhand stoping method, beginning on the level and mining upward. When the pillar stope had advanced two sets, the stringers beneath were to be reclaimed as waste filling was turned in, this procedure to be followed until the stope was carried up to the floor above. The supposition was that a stope of this character would hold heavier ground than the Mitchell (although not quite so heavy as that supported by a square set), thus acting as an intermediate stoping method between the Mitchell and square-set systems.

The objection to this method was that work would be started on the 1400-ft. (426-m.) level, beneath a pillar of ore two sets in width by ten sets long by 100 ft. (30 m.) high, which, aside from the weight of the capping, had 60 ft. (18 m.) of gob above it on the 1300-ft. (396 m.) level. It would be necessary, therefore, for the timbers in this stope (which would be started on the 1400-ft. level) to support this total weight. A pillar of ore two sets by ten sets by 100 ft. high weighs approximately 6722 tons. The weight of 60 ft. of gob on top of this ore is in the neighborhood of 2016 tons, making a total weight of 8738 tons (aside from the capping), which would have to be supported when work was commenced on the 1400-ft. level.

In using the Mitchell system, the timbering immediately below the 1300-ft. level had to support only a weight of 2016 tons, which is a little less than one-quarter of the weight to be sustained by the timbers when using the other method. This 2016 tons (in addition to the capping) was the entire weight to be supported until the pillar was taken down 50 ft. (15 m.), when the timbering was again thoroughly braced before waste filling was turned in; and while this filling naturally added to the weight, it was gob, rather than ore in place. Aside from this objection, ore could be mined by the Mitchell stoping method a great deal faster and at a lower cost than by this overhand modification.

Underhand Stoping Method

This system was used in the small orebody to mine out caved ore, also in places in the large orebody, where the ground showed signs of caving. It is used only in exceptional cases, but has proved very successful in all places where the ore is badly broken.

General Stoping Plan

After a consideration of the various systems, the following stoping methods were adopted: Overhand square-set method, for very heavy ground, approximately 50 per cent.; Mitchell stoping method, wherever weight of ground will permit, approximately 50 per cent. In exceptional cases, caved and badly broken ground will be mined out by the underhand square-set method. The principal stopes and workings of both orebodies are located on the 1300-ft. and 1400-ft. levels. Mining operations have not as yet been extended to the lower levels. The small orebody will be mined by the overhand square-set method, carrying up sections only two to three sets in width.

Bonanza, or Large Orebody

The principle followed on both levels is that the old filled square-set stopes are taken as the center of a circle and the newer stopes proceed

from the mined area toward the circumference. On the 1300-ft. level, the Mitchell stopes will be used immediately surrounding the old stoped area while square-set stopes will be used in very heavy ground, or where the walls of the orebody are not self-sustaining. On the 1400-ft. level, narrow square-set sections, two sets in width, will principally be used, the weight of the ground being too heavy to permit of the Mitchell system

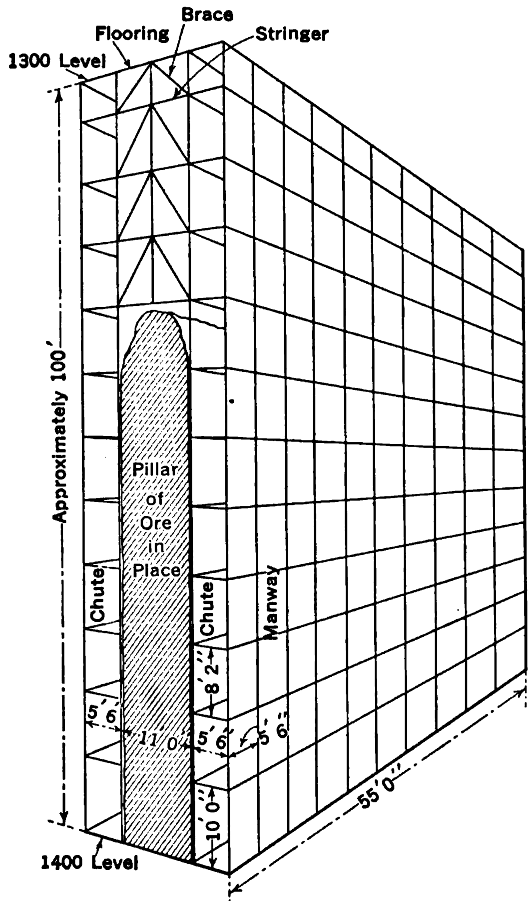

FIG. 1.—TWO ROWS OF SQUARE SETS WITH PILLAR OF ORE BETWEEN.

being used extensively. However, in exceptional places this system will be used. In broken ground, where a great weight must be sustained, the underhand square-set system will be used.

The stoping on the 1300-ft. level is always to be kept ahead of that on the 1400-ft. level so that the stopes on the 1300-ft. are finished before those on the 1400-ft. are brought up to this level. The sills are to be left in on both the 1300-ft. and 1400-ft. levels in order to keep down the repair

cost and so that drifts may be kept open for waste filling in the stopes beneath. A waste raise has already been put through to the surface and a large pit started to supplement the waste filling obtained from ordinary development work in the mine.

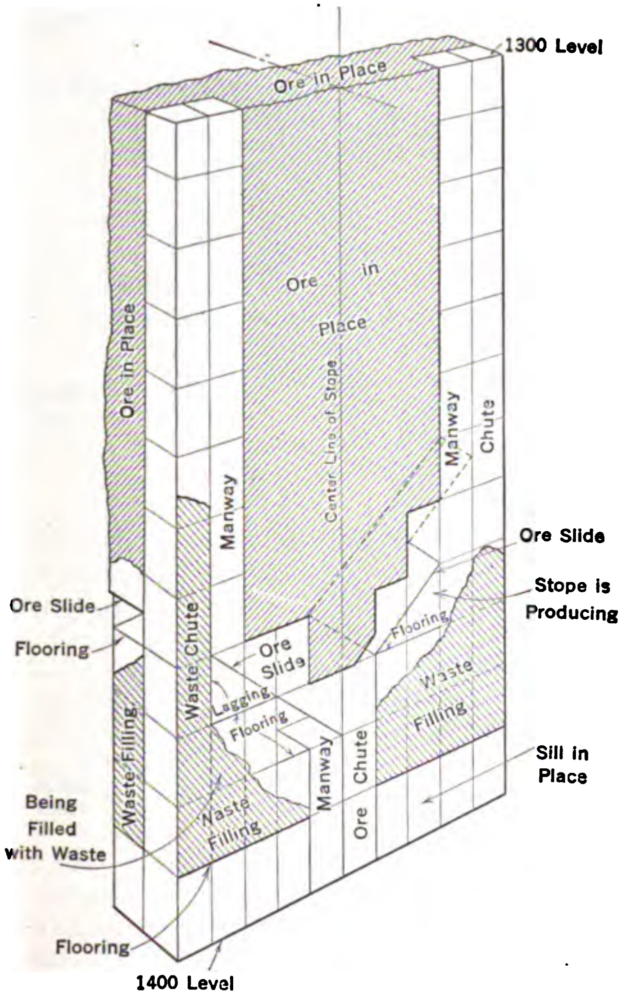

FIG. 2.—METHOD OF USING SQUARE SETS.

The Mitchell stopes consist of parallel leads of square sets, one set in width, separated by solid pillars of ore 11 ft. to 16 ft. (3.4 m. to 4.8 m.) (two to three sets) thick. These narrow sections of square sets are carried up to the capping and contain chutes every second or third set, through which the ore from the square sets, and later from the pillars between, will be taken out. The pillars of ore are left intact until the leads of square sets on either side have been mined out, and, with the

exception of the chutes, filled with waste. The pillars are then mined out. Timbers with angle braces are put in at the top of the pillar to hold the capping and mining is commenced at the top, using Jackhamers. After the ore in the pillar is removed, and as the waste filling is being turned in from above, tugger hoists are used to reclaim the long stringers,

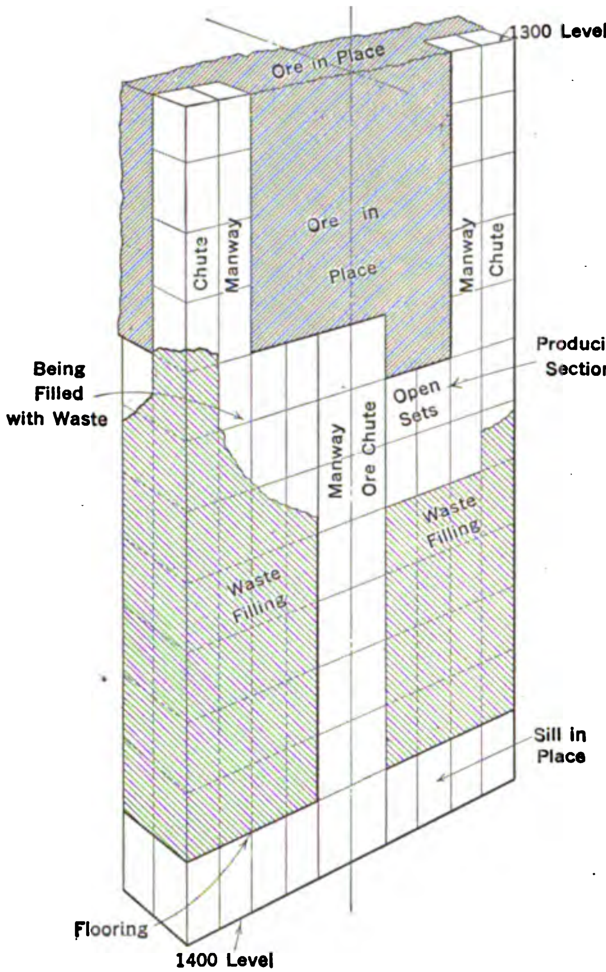

FIG. 3.—SQUARE-SET STOPE IN EXTREMELY HEAVY GROUND.

which can be used again. When the stope is completed, a barrier of waste, containing no timber (other than the floor), will exist between the leads of square sets originally put in and serve as a fire break.

Mitchell stopes will also be started on the 1400-ft. level, directly under stopes on the 1300-ft. level which have previously been mined by this system, in order to carry continuous barriers of waste from one level

to the next. These stopes will necessarily be heavier than those above the 1300-ft. level as the overburden consists of 60 ft. of waste filling, in addition to the weight of the capping. In order, therefore, to hold the weight, they will be carried up as shown in Fig. 1, which illustrates a section consisting of two rows of square sets with an 11-ft. (3.4 m.) (two sets wide) pillar between. After the pillar has been taken down approximately 50 ft. (15 m.), a floor will be laid, the space filled with waste, and the timbers reclaimed; then the remainder of the pillar will be taken down and the rest of the timbers reclaimed as the waste is poured in.

Where square-setting is used, the stopes will be carried two to three sets in width and about five to ten sets in length. Sufficient chutes will be put in, and in certain cases, slides built to these chutes, to eliminate mucking as far as possible (see Fig. 2). All the square-set stopes in extremely heavy ground will be two sets in width and taken any convenient length, as shown in Fig. 3. These small square-set stopes, even though they are only two sets in width and from five to ten sets in length, are taken up at least 50 ft. before the adjacent section is started, in order to prevent the ore from breaking in large blocks and causing side weight against the newer stopes.

The main raise is first driven through from one level to another. This contains standard manway, chute, and timber compartment. After that, chutes, or raises, are carried up as the stope progresses. With slides, waste filling may be turned into one-half of the stope while the other half is producing. Later, the work is reversed, and this process is followed continuously until the level above is reached, each half of the stope alternately producing and being filled with waste.

Ventilation

There are three shafts on the property, Little Daisy, Edith, and Audrey, and two raises to the surface, one for ventilation and the other for waste. The Audrey, when completed, will be the main hoisting shaft; the Edith, the supply shaft; while the Little Daisy is used entirely for ventilation. One suction fan, having an air capacity of 40,000 cu. ft. (1120 cu. m.) per min. is located at the top of the Little Daisy shaft, and a second, having a capacity of 135,000 cu. ft. (3780 cu. m.), will be installed at the top of the air raise, which will become the main air-shaft. A connection will be made from the long tunnel directly to the large ore-body on the 1300-ft. level. A raise will be driven from the 1400-ft. level, connecting at this point, so as to force all the fresh air entering the large tunnel down to the lower workings. Doors have been put in at the different shaft stations on the 800-ft., 1100-ft., and 1200-ft. levels in order to force all the air to pass through the different stopes.

Measures will also be taken for the proper coursing of the air through the Bonanza orebody, where it is most needed. Gangways, immediately beneath the capping and connecting old raises, have been preserved by building walls of waste rock. These are maintained solely for ventilation purposes and will remain open for some time in order to afford a means of escape for the heated air from the old square-set sections.

While at present the temperature, humidity, and velocity of the air in the different working places fall somewhat below the requirements for a good working atmosphere, when the necessary development work is completed, standard raises built, and the large mine fan installed on the surface, the volume of air passing through the workings will amount to at least 400 cu. ft. (11.3 cu. m.) of air per man per minute and the United Verde Extension will be one of the best ventilated mines in the Southwest.

Fire Protection

A spraying system has been installed in the Edith shaft. In case of fire in this shaft, the fire-doors on the 1300-ft. and 1400-ft. stations will be closed immediately by means of compressed air and the sprays, which are controlled from the surface, put in operation. The doors on the 800-ft., 1100-ft., and 1200-ft. levels are ventilating doors and always kept closed. The mine fans would also be closed down at once, but not under any other circumstances.

The Little Daisy shaft, which is used entirely for ventilation, has a concrete connection from the fan to a depth of one set below the collar. From there down it is naturally so wet as to make the installation of a fire protection system unnecessary. The new Audrey shaft is fireproofed by means of concreting. The barriers of waste left by the Mitchell stoping method will serve as fire-breaks in that part of the Bonanza orebody in which this system is used.

A number of electric blowers, and a sufficient supply of bulkheading material and fire-fighting equipment, are kept on hand so that the fire area can immediately be put under pressure and steps taken to extinguish the fire. Should these measures fail, the general procedure will then be similar to that followed in mining out the fire area in the small orebody, from which, for 1½ yr., ore that was actually on fire was mined successfully under pressure without interfering with the production or the daily mining operations of the rest of the mine. During this time not a single serious injury was reported.

Haulage

A series of parallel drifts 50 ft. apart traverse the entire orebody on the 1400-ft. level, which is the main haulage level, and connect into a large motor haulage drift, which extends to the Audrey, or main hoist-

ing shaft. The stopes are located at right angles to these parallel drifts in order to facilitate the handling of ore.

The raises between the 1300-ft. and 1400-ft. levels will be used as storage chutes for all ore above the 1300-ft. level. All ore above the 1400-ft. level will be drawn out in motor cars on the main haulage level, taken to the Audrey shaft, and dumped into ore pockets. In the course of time, when the 1500-ft. and 1600-ft. levels are developed, the 1600-ft. will be the next main haulage level.

At present, the ore is being hoisted in skips to surface and transported over the aerial tramway, but when the large haulage tunnel on the 1300-ft. level (now being driven) is completed, the ore will be hoisted to the 1100-ft. and dumped into pockets, whence it will be drawn out on the 1300-ft. level into standard-gage railroad cars and taken direct to the smelter.

Conclusions

The general stoping plan just outlined presents the following advantages:

Safety.—Stopes will be carried small and the process of filling with waste will keep pace with the stoping in order to avoid a possible cave.

Ventilation.—Gangways, immediately under the capping, will permit the escape of heated air from the old filled stopes. Sufficient raises, containing standard manways and timber compartments, will be carried up in all working stopes to furnish an adequate supply of fresh air in each working place. All the air entering the mine will be coursed through the stopes.

Fire Protection.—Adequate means of fire protection has been provided for all shafts. In the Mitchell stopes, barriers of waste separate the square-set sections; these are absolutely necessary in order to localize a fire area in the event of an outbreak. Equipment for an auxiliary ventilating system will always be kept on hand in order that any section of the orebody may be operated under pressure in case of necessity.

Efficiency and Economy.—As all stopes must be filled with waste, a large waste pit on the surface is available, from which a supply may be obtained at any time. Mucking will be largely eliminated by the use of extra raises, slides, etc.

In the Mitchell stopes, considerable timber will be saved by reclaiming the stringers when the stopes are filled. The ore will also be extracted from the pillars more rapidly and at a lower cost than with ordinary square-setting.

A large number of stopes will always be available from which the smelter may be furnished with a continuous supply of ore containing the necessary chemical contents. By leaving the sills intact, drifts can be maintained without an excessive expenditure for repairs. Where these

have been removed, the drifts are very heavy and are kept open with great difficulty.

As all the ore above the 1400-ft. level will be dumped direct into the regular ore chutes between the 1300-ft. and 1400-ft levels, and from there be drawn out into motor cars, it will not be necessary to have large separate ore pockets between these levels. This general plan of stoping, arrangement of chutes, and motor drifts, may also be continued in the deeper levels as the work progresses downward.

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Natural-gas Storage

BY L. S. PANYITY,* COLUMBUS, OHIO

(New York Meeting, February, 1919)

The question of natural-gas supply is receiving careful consideration in many parts of the country, as in the winter months it is quite a problem to have on hand sufficient gas to satisfy the demand. Increasing the output of wells by the application of vacuum has been tried with various results and large companies have attempted to keep up the supply with gas compressors. The possibility of storing natural gas in the sands of exhausted gas pools has been tried in a few instances with satisfactory results. This method may prove of practical value in solving the problem, especially in the case of towns that formerly obtained gas from their immediate vicinity, but now must search for new pools.

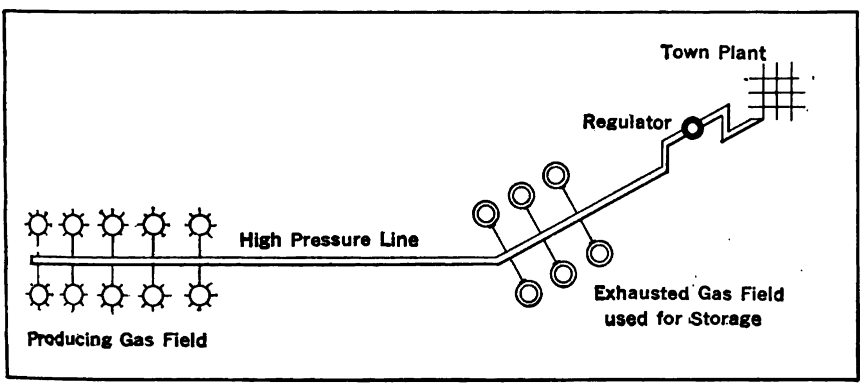

FIG. 1.

In all cases, only part of the available supply is utilized during the warm weather, so that many wells are shut-in, yet during the winter months, the supply is not sufficient even with all the wells on the line; in such cases it would be of great value if a large volume of stored gas were on hand, obtained through wells that would have been standing idle during the summer.

Idle producing wells having considerable "rock pressure" will force gas into the exhausted, or storage wells, and this gas will be used only when the regular supply falls short (Fig. 1). If two gas wells of different

* Geologist, Ohio Fuel Supply Co.

pressures are connected, the one having the greater pressure will feed the other, until the pressures are at an equilibrium. The same results will be obtained if an exhausted gas well is connected to a high-pressure gas line. High-pressure lines equipped with regulators near the town plant have considerable pressure, so that storage wells connected to such a line will receive gas from the line as long as the line pressure is greater than the well pressure. During a period of heavy consumption of gas, the pressure

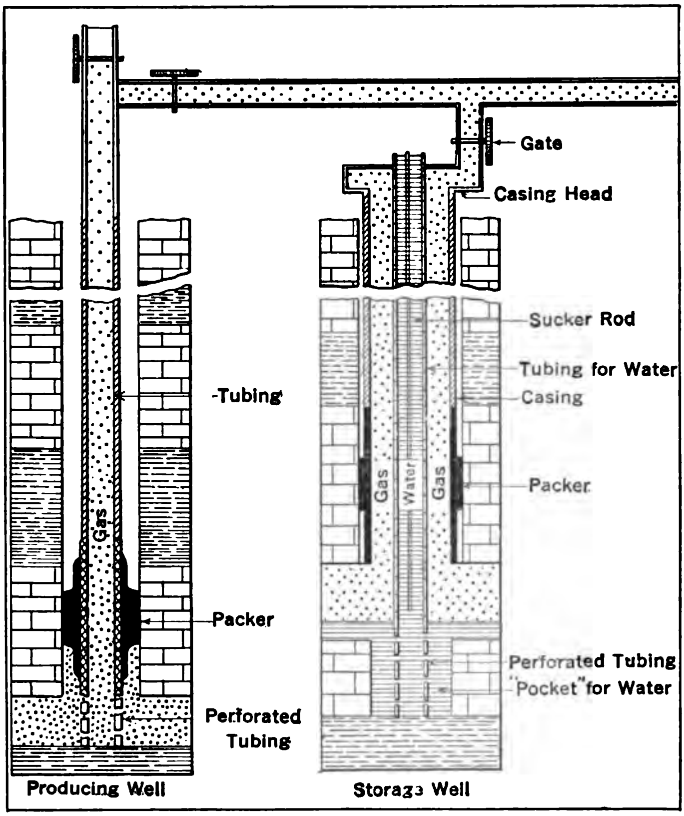

Fig. 2.

on the main line is greatly reduced, so that gas from the storage wells will flow into the lines. An arrangement of this kind will work automatically, the flow of gas into or from the storage wells depending on the pressure carried in the line.

It is advisable in most instances that the flow into and from the storage wells be regulated by means of gates, instead of automatically. In addition, the volume of gas should be metered as it is forced into or passes from the wells; the pressure also should be noted. By properly chart-

ing the meter and pressure records, the characteristics of the individual wells may be determined.

The geological conditions existing in the storage field, as well as in the producing field, must be taken into consideration. Best results are obtained where the storage reservoir is in a shallow sand and the producing horizon is deeper, so that the producing sand will have a higher pressure. This will have a tendency to reëstablish the original rock pressure in the artificial reservoir. It is unlikely that a rock pressure greater than that which existed originally can be obtained. A lenticular-shaped sand body is preferable, as a good control over the entire reservoir is necessary. The location of all wells that have been drilled must be known and put in such a condition that they may be used; if this is not possible the wells must be properly plugged.

In some instances the sand used for storage may make large quantities of water; a difficulty that may be overcome by pumping. Best results are obtained by drilling a pocket below the sand in which the water may accumulate and from which it may be pumped through the working barrel, in the same way as it is customary to pump oil; the storage and recovery of the gas being through the casing-head (Fig. 2).

This storage method may be used to advantage in many towns; for instance, Tiffin, Ohio, formerly the center of a large gas-producing area, but now dependent on outside sources, which in times of great demand are not sufficient for the needs of the town. It may be possible to find nearby an exhausted gas pool in such condition that this method may be tried. The system allows considerable latitude and may be installed to suit the requirements of the particular case.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
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DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Automatic Copper Plating

BY JOSEPH W. RICHARDS,* SOUTH BETHLEHEM, PA.

(New York Meeting, February, 1919)

PLATING iron with copper has received great attention from practical and scientific men, but, aside from the deposit secured by immersion of iron in copper salts, by electro-plating, or by welding together thin sheets of iron and copper, these efforts have met with no success.

Failure of these efforts, in the production of copper plating, has been due to the fact that the conditions normally and necessarily present in the plating operation are antagonistic to the production of copper-plated iron. In most, if not quite all of them, a bath of molten copper has been used. The temperature of a molten copper bath is so high that the iron becomes oxidized before it can be immersed in the molten copper, and unless a protective flux for the molten copper is used, the surface of the copper will become oxidized, and, in any event, the plated iron will oxidize immediately on its being withdrawn from the molten bath.

I recently had the pleasure of visiting the works of The Metals Plating Co. at Elizabeth, N. J., where I witnessed the plating of iron sheets with copper by a new process.[1] The plating metal is applied to the sheet in the form of a liquid mixture by means of rolls, such as inking rolls. The sheet, after being coated with the mixture, is automatically carried forward and deposited on a link-belt conveyor, which carries it through a furnace maintained at a temperature well above that of molten copper. The basic principle involved in this method lies in the application of the plating metal to the sheet while the sheet is cold and then melting the metal in place on the sheet under conditions which are favorable to the formation of the plating.

The Plating Mixture

The liquid plating mixture is composed of either copper oxide or finely divided copper, or a mixture of both, ground to the consistency of a light varnish in a crude oil having an asphaltic base, of a specific gravity of from 14° to 16° Bé. The plating mixture which gives the best results

* Professor of Metallurgy, Lehigh University.

[1] U. S. Patents 1197693, 1197694, 1197695, Sept. 12, 1916, to William E. Watkins.

consists of 4 lb. (1.8 kg.) of copper oxide ground together with 4 lb. of finely precipitated copper, and made to the consistency of a light varnish by grinding it in 1 gal. (3.8 l.) of Mexican crude oil of specific gravity of 14° to 16° Bé. It is found that the asphaltic base of this oil has reducing power sufficient to reduce the the oxide of copper to metal, in the furnace, and to protect the precipitated copper from oxidation during the operation; also to reduce any oxide of iron that may have been on the sheet. One gallon of oil can reduce 5 lb. of copper oxide.

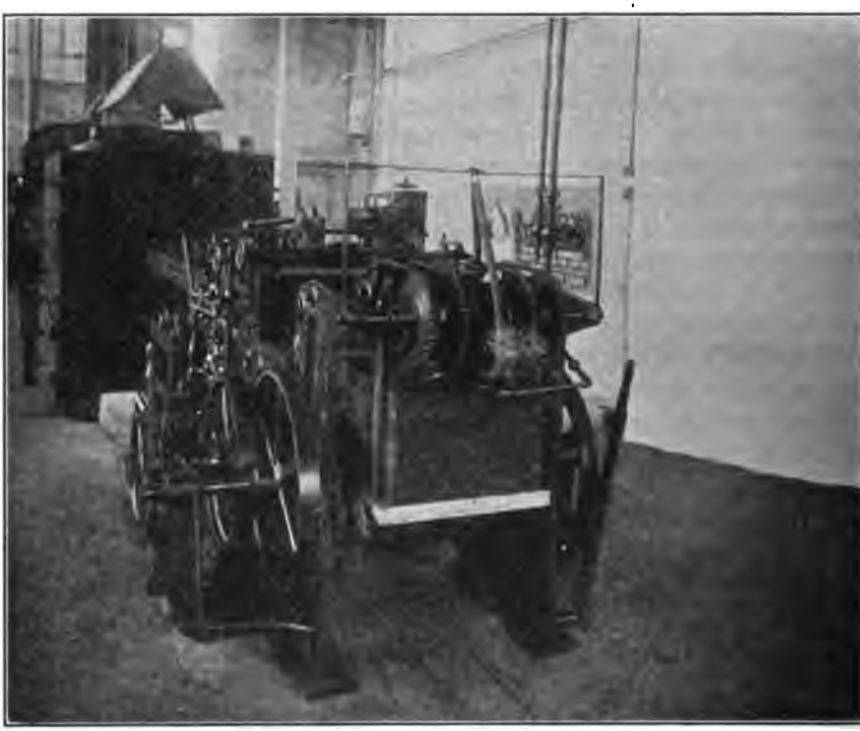

FIG. 1.—THE SHEET-FEEDING MACHINE AND COATING ROLLS.

This mixture has also been found to have the proper viscosity for its application to the sheet by coating or inking rolls, and to hold it uniformly on the sheet when exposed to the furnace temperature so as to produce a uniform deposition of strongly adherent copper upon the sheet. A number of variations of this mixture have been used, such as using copper oxide only, mixed with powdered charcoal, or using precipitated copper only without any copper compound. Mexican crude oil is probably the cheapest liquid to use, suitable for this purpose, but other liquids of similar properties have been used with nearly equivalent results.

The Automatic Feeding and Plating Machine

As the boxes of sheets are placed on the platform of the machine, it is necessary to lift the sheets one by one and feed them, like feeding paper to a printing press. This can be done by hand but has been accomplished very satisfactorily by an automatic sheet-feeding machine which has been worked out by Mr. Conran, the company's superintendent. The platform on which the stack of sheets is placed is raised continually so that the top sheet is always at the same level. A suction cup comes into contact with the upper sheet and lifts it, while at the same moment a jet

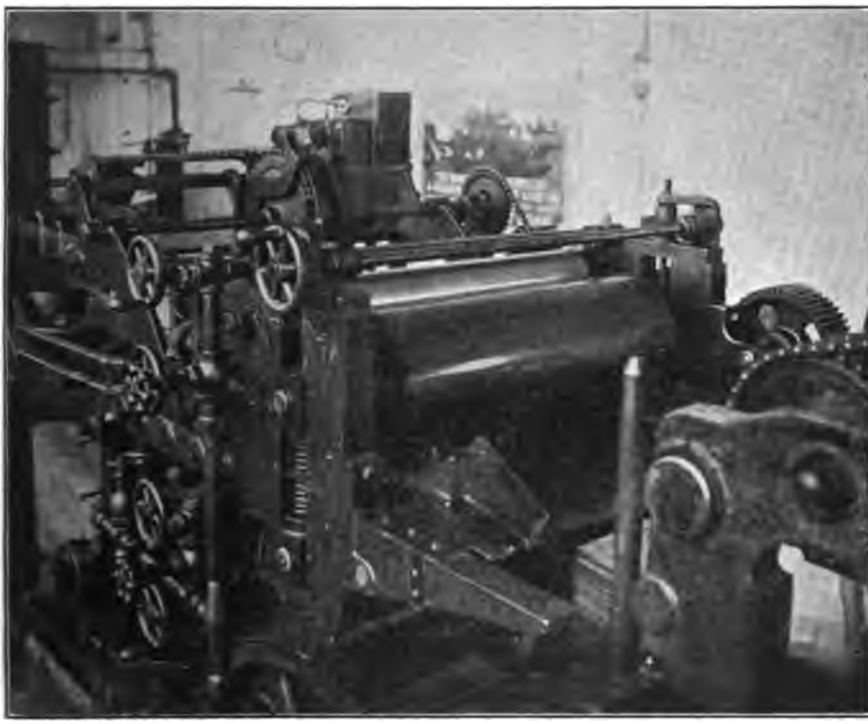

Fig. 2.—The coating rolls showing parallel adjusting gears.

of compressed air is introduced beneath the sheet to destroy the vacuum effect, or any other slight adherence between the sheets, thus freeing it from the sheet beneath. The suction cup raises the rear end of the sheet and forwards it into engagement with the coating rolls to receive the plating mixture. The sheet then travels forward and is deposited on the furnace conveyor, lateral fingers compressing the sheet into an arch, so that it passes into the furnace bowed, in a position and shape best suited for withstanding collapse when exposed to the heat existing in the furnace.

Parts of the carrier, such as the fingers that support the sheet, that are exposed to the greatest heat of the flame, are cast of nichrome metal, in order that they may withstand the temperature and the oxidizing influences of the flame.

While being carried through the furnace, volatile constituents of the paint upon the sheets distill, copper oxide in it is reduced to metal, and the copper unites with the iron to form a continuous coating. The atmosphere of the furnace is kept reducing in order to preserve the coat-

FIG. 3.—THE SHEET-ARCHING MACHINE AND FURNACE CONVEYOR, SHOWING BOWED SHEETS ON THEIR SUPPORTS ENTERING THE FURNACE.

ing as far as possible from oxidation. The carrier delivers the sheets to flattening rolls, which pass them on to another carrier operating at lower temperature, upon which they cool.

Articles of other shapes than sheets, such as wire and tubes, can likewise be copper plated on the same principle and by the use of similar continuous automatic apparatus. Other metals as well as copper, such as tin, lead, and alloys of different metals, can also be used as the plating metal.

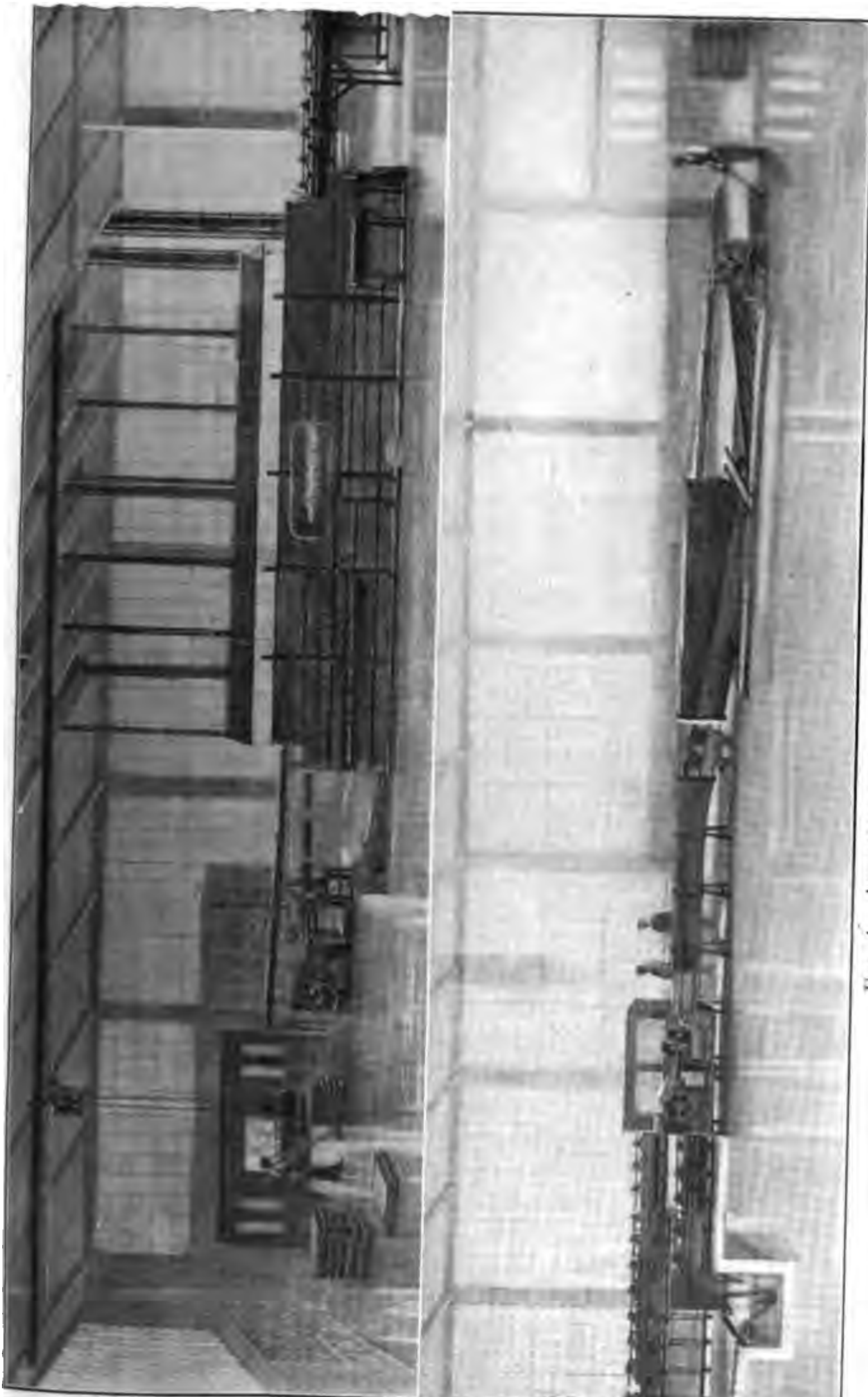

FIG. 4.—AUTOMATIC FEEDING AND PLATING MACHINE.

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Two Instances of Mobility of Gold in Solid State

BY EDWARD KELLER,* PH. D., NEW YORK, N. Y.

(New York Meeting, February, 1919)

Gold Movement on Surface of Auriferous Copper When Latter Is Subjected to Oxidation

Some years ago the writer's attention was called to the fact that rolling-mill scales from auriferous copper do not have the gold content proportional to the gold contained in the copper from which they are derived.[1] So, later, he made a few simple experiments, which are described herewith.

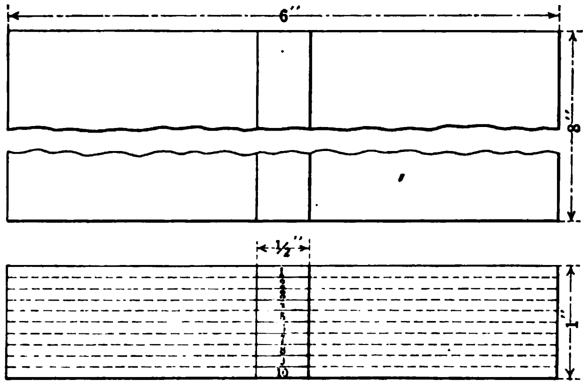
In order to test the gold movement on the changing surface of a copper plate under the influence of oxidation, plates 6 in. by 8 in. by 1 in. (15.2 cm. by 20.3 cm. by 2.5 cm.) of converter copper, refined, of 99.29 per cent. purity, and leaded copper with a content of 95.65 per cent. copper, were obtained. Ten cuts were made through the thickness of the plates along the longitudinal center and the silver and gold content ascertained in each of the 10 samples in both plates, as shown in the accompanying illustration. The assay results, recorded in Tables 1 and 2, show that the gold distribution is relatively uniform in both plates, while silver has greater variations, especially in the leaded plate. The plates subjected to oxidation were placed in a red-hot muffle for about 2 hr., two small scorifiers being used as supports. Arranged alongside each other, they nearly filled the width of the muffle, and so were practically under equal conditions of heat and draft. The accurate observance of the time was not possible, however, because of other work, but the time of the exposure of each plate in a pair was identical. At the end of each period, each plate was plunged into water and completely freed of scale, which was carefully collected, dried, weighed, and analyzed. Samples of the plates had also been taken of the molten metal and duly analyzed.

Table 3 contains the analytical data for the two plates and their several sheets, or layers, of oxide scales. These figures show that in the oxidations of the converter copper the silver is fairly uniform, while

* Metallurgical chemist.

[1] H. A. Prosser, private communication.

the gold is highly irregular and especially low in the first layer. In the oxidations of the leaded copper plate, the silver and gold contents are variable; however, this irregularity is due to two different causes. The fourteen oxidations with the converter copper plate and the five oxida-



METHOD BY WHICH SAMPLES WERE TAKEN.

TABLE 1.—*Converter Copper Plate*

Sample Number	Silver in Sample, Oz. per Ton	Gold in Sample, Oz. per Ton	Sample Number	Silver in Sample, Oz. per Ton	Gold in Sample, Oz. per Ton
1	77.1	0.34	7	75.6	0.32
2	76.4	0.34	8	75.8	0.34
3	76.1	0.34	9	77.4	0.34
4	76.5	0.32	10	77.3	0.34
5	76.3	0.34	Average	76.48	0.336
6	76.3	0.34			

TABLE 2.—*Leaded Copper Plate*

Sample Number	Silver in Sample, Oz. per Ton	Gold in Sample, Oz. per Ton	Sample Number	Silver in Sample, Oz. per Ton	Gold in Sample, Oz. per Ton
1	81.2	0.42	7	80.7	0.44
2	80.0	0.42	8	81.1	0.44
3	79.9	0.40	9	82.3	0.44
4	80.4	0.40	10	86.1	0.44
5	80.5	0.44	Average	81.27	0.428
6	80.5	0.44			

tions with the leaded copper plate left a residual plate approximately ¼ in. (6.3 mm.) thick in each case.

The figures given in Table 3 do not form a proper basis for comparison nor do they give the proper relation between the precious metals in the oxides and in the copper plates. The simplest way to show these rela-

TABLE 3.—*Analyses of Copper Plates and Layers of Oxide Scales*

Oxidation Sample Number	Converter Copper Plate				Leaded Copper Plate			
	Oxide, Grams	Copper, Per Cent.	Silver, Oz. per Ton	Gold, Oz. per Ton	Oxide, Grams	Copper, Per Cent.	Silver, Oz. per Ton	Gold, Oz. per Ton
1	410	86.93	68.20	0.040	1200	73.67	89.30	0.180
2	400	87.18	66.74	0.115	1110	78.79	66.84	0.245
3	550	87.71	67.75	0.125	1400	79.38	56.00	0.295
4	340	87.52	66.74	0.305	1040	79.32	60.28	0.215
5	390	87.83	65.94	0.110	800	78.91	54.52	0.230
6	580	88.01	64.65	0.230				
7	350	87.79	65.75	0.230				
8	435	87.96	64.76	0.215				
9	455	88.09	65.76	0.340				
10	420	87.77	66.01	0.415				
11	455	87.95	67.32	0.260				
12	395	87.60	65.31	0.300				
13	390	88.03	65.14	0.265				
14	375	88.00	64.90	0.285				
Plate...	....	99 29	76.30	0.315	....	96.65	81.00	0.410

TABLE 4.—*Data in Table* 3 *Converted to Basis of Cu* = 100

Oxidation Sample Number	Converter Copper Plate				Leaded Copper Plate			
	Copper in Oxide, Grams	Copper, Per Cent.	Silver, Oz. per Ton	Gold, Oz. per Ton	Copper in Oxide, Grams	Copper, Per Cent.	Silver, Oz. per Ton	Gold, Oz. per Ton
1	365.4	100	78.45	0.046	884.0	100	121 22	0 244
2	348.7	100	76.55	0.132	874.6	100	84.83	0.311
3	482.4	100	77.26	0.143	1111.3	100	70 55	0 372
4	297.6	100	76.26	0.348	824 9	100	76.00	0.271
5	342.5	100	75.08	0.125	631.3	100	69.09	0.291
6	510.5	100	73.46	0.261				
7	307.3	100	74.89	0.262				
8	382.6	100	73.63	0.244				
9	400.8	100	74.65	0 386				
10	368.6	100	75.21	0.473				
11	400.2	100	76.54	0.296				
12	346.0	100	74.55	0.342				
13	343.3	100	74.00	0 301				
14	330.0	100	73.75	0 324				
Average	373.8	...	75.30	0.2605	865.1	...	84.62	0.3024
Total...	5225.9	...	.....	......	4326.1			
Plate...	......	100	76.85	0.317	......	100	84.68	0.428

tions is to transform these analytical figures to the basis of Cu = 100; the result is given in Table 4. The silver and gold is now directly comparable between each oxidation and the original copper plate, also

the silver and gold content in each oxide layer now pertaining to the copper that was oxidized. In the converter copper plate, the silver is fairly uniform in the several oxide layers and of about the same content as the average of the original plate; in other words, under the influence of oxidation of the copper, the silver is practically immobile. The gold is not only irregular but ranges from a minimum of 0.046 oz., in the first oxide layer, to a maximum of 0.473 oz., in the tenth layer. The correct average of the gold in all the oxidized copper of the converter copper plate is 0.2605 oz. per ton, or 82.2 per cent. of the 0.317 oz. per ton, which is the average gold for the whole plate. It follows, therefore, that at no stage of the oxidation was all the gold taken up by the oxide scales while some must have retreated and concentrated on, or in, the residual plate. For the leaded plate, Table 4 shows great variations in silver for the several oxidations. That these differences are not due to the mobility of the silver has already been indicated. Lead is not soluble in solid copper and in a copper-lead plate, like the one under consideration, most of the lead is retained mechanically on account of the rapid chilling after casting in a cold metallic mold. The mechanically contained lead appears to be under strain, for when the plate is reheated to redness the lead begins to ooze out at the top as well as the bottom, showing that other forces besides gravity are operative. Silver is more soluble in lead than in copper and moves from the inner plate outward with the molten lead as carrier. This fact was proved in a special test with a similar plate. The lead drops on the surfaces of the plate were collected before the copper had formed any appreciable oxide layer and their silver content was found to be 635.3 oz. per ton. The outward movement of the lead in the plate is confirmed, too, by the lower copper content of the first oxide layer, compared with the others, and by the higher copper content of the residual plate, compared with the original plate. The silver carried by the lead contains no appreciable amount of gold, so while the lead and the silver move outwards in the molten state, the gold concentrates toward the solid copper of the residual plate, even to a greater degree than in the case of the converter copper plate. The average gold content for all the copper oxidized in this plate is 0.3024 oz. per ton, or 70.65 per cent. of the average gold contained in the whole plate, which is 0.428 oz. per ton.

What has been proved of the gold movement toward the residual plates by the figures just given should also be proved by the analyses of the residual plates themselves. However, these residual plates, which were approximately ¼ in. (6.3 mm.) thick, had samples planed from the top and bottom surfaces and these, as also one from the finally remaining plate, were analyzed, but the weights of the respective parts were not taken, so that a proper average of the assays cannot be given. Nevertheless, the results are given in Table 5.

TABLE 5.—*Analyses of Residual Plates*

Location of Sample	Converter Copper Plate			Leaded Copper Plate		
	Copper, Per Cent.	Silver, Oz. per Ton	Gold, Oz. per Ton	Copper, Per Cent.	Silver, Oz. per Ton	Gold, Oz. per Ton
Top surface	99.33	77.77	0.53	97.77	72.80	0.48
Bottom surface	99.38	75.35	0.35	97.70	72.30	0.58
Inner plate	99.55	78.20	0.41	98.12	69.61	0.34

Cast Copper, Quenched, Richer in Gold than Molten Charge

Most of the converter copper now shipped from the smelteries in the form of anodes, bars, etc. is subjected to the so-called pickling process; that is, the red-hot castings are plunged into water, in which they shed most of the oxide scales that have formed on their surface. That the first layer of oxide, or scales, formed contains only about one-tenth of the gold in the original copper has been conclusively proved in the tests with the converter-copper plate. No data available show the commercial magnitude of this problem but the first layer of scales in the oxidation of the experimental converter copper plate may, perhaps, be an index of what takes place on a larger scale in metallurgical practice. The original plate was not weighed, but from its dimensions, 6 in. by 8 in. by 1 in., and the assay results the following data and conclusions are obtainable:

Weight of original plate, pounds	14.4
Weight of copper in first oxide scales (365.4 gm.), pounds	0.8
Weight of remaining plate, pounds	13.6
Gold in original plate, ounces per ton	0.315
Gold in copper of first oxide scales, ounces per ton	0.046
Weight of gold in original plate, ounces	0.002268
Weight of gold in first oxide scales, ounces	0.000018
Weight of gold in remaining plate, ounces	0.002250
Gold in remaining plate, ounces per ton	0.331
Gold in original plate, ounces per ton	0.315
Enrichment of remaining plate, ounces per ton	0.016
	=5.08 per cent.

This last figure, of course, will decrease with the increase of the thickness and weight of the plates or with the decrease in the thickness of the layer of oxidized copper. In the latter case, however, the scales would become poorer in gold, which would relatively increase the enrichment of the remaining plate. The thickness of the layer of copper oxidized in this experimental case approximates $\frac{0.75}{28} = 0.027$ in.; where

TABLE 6.—*Monthly Averages of Western Shotted and Eastern Drilled Samples of Refined Converter Copper*

Month No.	Copper		Difference		Silver per Ton		Difference		Gold per Ton		Difference	
	Western Shotted Sample, Per Cent.	Eastern Drilled Sample, Per Cent.	Over, Per Cent.	Under, Per Cent.	Western Shotted Sample, Ounces	Eastern Drilled Sample, Ounces	Over, Ounces	Under, Ounces	Western Shotted Sample, Ounces	Eastern Drilled Sample, Ounces	Over, Ounces	Under, Ounces
1	99.3499	99.2922	......	0.0577	88.6736	88.9444	0.2708	......	0.5147	0.5226	0.0079	
2	99.3116	99.3077	......	0.0039	83.4784	83.5366	0.0582	......	0.4791	0.4903	0.0112	
3	99.2796	99.2864	0.0068	......	86.2927	86.2737	......	0.0190	0.4958	0.5052	0.0094	
4	99.2730	99.2987	0.0257	......	86.7758	86.8622	0.0864	......	0.4738	0.4814	0.0076	
5	99.2525	99.2589	0.0064	......	91.4387	91.4119	......	0.0268	0.6244	0.6400	0.0156	
6	99.2621	99.2612	......	0.0009	91.3735	91.4701	0.0966	......	0.5599	0.5665	0.0066	

0.75 in. is the thickness of all the copper oxidized and 28 the number of layers of scales produced by the 14 oxidations. It is not likely that this figure is reached in actual metallurgical practice.

Figures are available for copper sampled from the molten furnace charges and by drilling the pickled anodes. The samples by these methods are acknowledged to be correct and the assays were made by identical standard methods. Table 6 gives such a comparison on monthly runs for 6 mo.[2] The gold assays at the eastern end, made on drill samples from anodes, are uniformly higher than those of the west, where the assays were made on shotted samples from the furnace charges. These differences, though, are so small that they may be accidental or due to personal factors and render the point raised essentially academic; yet the factor undoubtedly exists and possesses the same algebraic sign at all times.

Speed of Oxidation of Copper Containing Impurities

The figures given plainly demonstrate that the copper of the leaded plate was much more quickly oxidized than the copper of the purer converter-copper plate and that the copper in the former was transformed approximately into cupric oxide while in the latter it remained essentially in the form of cuprous oxide. Table 7 gives the ratios of copper oxidized and of the oxygen taken up by the copper in the several plates. An additional test was made with a pair of plates, one of which was identical with the converter copper in the other tests, while the second contained approximately 1 per cent. of arsenic. The oxidation was

TABLE 7.—*Speed of Oxidation of Copper in Plates*

Month of Oxidation	Converter Copper Plate, Copper Oxidized, Grams	Leaded Copper Plate, Copper Oxidized, Grams	Copper Ratio	
			Converter Copper Plate	Leaded Copper Plate
1	365.4	884.0	1	2.42
2	348.7	874.6	1	2.51
3	482.4	1111.3	1	2.30
4	297.6	824.9	1	2.77
5	342.5	631.3	1	1.84
Total	1836.6	4326.1		
Average	367.5	865.2	1	2.35
			Oxygen Ratio	
Oxide, grams	2090.0	5383.5*		
Copper, grams	1836.6	4326.1		
Difference	253.4	1057.4	1	4.17

* Original oxide less 3 per cent. allowance for lead.

[2] E. Keller: Principles and Practice of Sampling Metallic Metallurgical Materials, U. S. Bureau of Mines, *Bulletin* No. 122 (1916), 16, 74.

performed at a much lower temperature than in the former tests, therefore the smaller quantity of copper oxidized in about equal time. Of the converter copper, 73.79 gm. of copper were oxidized and 185.44 gm. of the arsenated plate, giving a ratio of 1 : 2.51.

Formerly copper sulfate (bluestone) was produced by oxidizing copper shot or granules in reverberatory furnaces and dissolving the finally obtained cupric oxide in sulfuric acid, etc. Comparatively pure and impure coppers were used, the latter having the advantage of much more ready oxidation. However, the disadvantage of the slow oxidation of the purer copper was overcome by converting it into hollow shot with very thin shell, thus enormously increasing its oxidizable surface. Pure copper, when molten, absorbs large volumes of sulfur dioxide, which is emitted upon cooling; therefore, when a jet of cold water, or air, strikes a stream of molten copper saturated with the sulfur dioxide the resulting shot are hollow. This absorbent power of pure copper for sulfur dioxide diminishes as other impurities increase and hollow shot cannot be produced from very impure copper.

Explosive Condition

In one of the series of tests, the two plates were left in the muffle for about double the usual time. When the converter copper plate was plunged into water, it shed its scales a little more noisily than usual but when the leaded plate was immersed, there was a loud report, the hand of the manipulator received a shock, and his eyes were firmly closed for some moments. The eyes, however, were absolutely uninjured and the very finely divided copper oxide that had struck the face with considerable force caused little irritation. The water bucket, though, was broken into numerous pieces.

There was an essential difference in the character of the scales of the two plates. Those from the converter-copper plate were relatively hard and remained in compact pieces of some size, while the scales from the leaded plate generally disintegrated into powder when striking the water. This suggests that the explosion was due to the enormous surface of the increased quantity of the red-hot oxide powder, spontaneously evolving a great volume of steam. This incident is recorded merely to call attention to what might happen if tons of similar material were plunged into a bosh.

Gold Movement on Surface of Auriferous Silver when Latter is Dissolved in Nitric Acid

It is generally known that in silver-gold alloys the silver is soluble in nitric acid when the alloy contains about 30 per cent. or less of gold and that in the higher grade of alloys comparatively strong nitric acid may be used without disintegrating the gold. As the gold content decreases and nitric acid above a certain strength is used, disintegration will take place. However, for the whole series of alloys down to 1 per cent. or even less of

gold, a proper strength of nitric acid and heat will dissolve the silver and leave the gold in such a coherent state that it represents the exact shape of the original bead, although very much reduced in size when little gold is present. Therefore it may be said that, with decreasing gold content in the silver-gold bead the more marked will be the gold movement in the direction of the retreating surface of the silver under the solvent action of the nitric acid.

Bearing on Accuracy of Gold Assay

The assay silver-gold beads derived from the greater part of the converter copper now produced contain about 1 per cent. of gold. Unless the gold is obtained in coherent form in the parting operation there are almost unavoidable losses in the decanting manipulations and a resultant low gold assay. For example, when such low-grade assay beads are left in cold dilute nitric acid, nine parts water to one part nitric acid (sp. gr. 1.42), until all the silver is dissolved, the gold will be completely disintegrated. The same dilute nitric acid is the best solvent for preserving the gold in the desired state, when it is brought to the temperature of boiling water as quickly as possible after the assay bead is immersed. The higher temperature evidently increases the gold mobility.

Influence of Impurities in Silver on Gold Mobility

Silver-gold assay beads derived from silver chloride and metallic gold by the customary operations of scorification and cupellation have a silver fineness, after deduction of the gold, of 996 to 998.5 per thousand. Titrations and analyses have confirmed these figures. An analysis of 30 gm. of such beads showed them to contain 0.16 per cent. lead and 0.15 per cent. bismuth, the latter metal having concentrated in the silver from the test lead, which at the time contained approximately 0.02 per cent. of that metal. Assay beads of not less than 997 silver fineness offer no difficulty in the gold assay, but when the silver falls to 990 or lower, the gold cannot be obtained in any other form than powder, no matter what acid and heat combinations are employed.

TABLE 8.—*Assays of Copper Anode Residues*

Origin	Hot Scorification and Cupellation		Cool Scorification and Cupellation	
	Silver, Oz. per Ton	Gold, Oz. per Ton	Silver, Oz. per Ton	Gold, Oz. per Ton
In beads	3613.12	28.030	3688.85	27.815
In slags	55.38	0.010	56.44	0.020
In cupels	21.64	0.045	20.93	0.025
In decantation	....	0.075	....	0.225
Total	3690.14	28.160	3766.22	28.085

Much difficulty was formerly encountered in obtaining concordant results for silver and gold in the assay of the same sample of copper-anode residues by the all-fire method. There were always disagreements, reading, "high silver, low gold" or "low silver, high gold." Table 8 gives the averages of 20 individual assays for each case. As the pyrometer has not been introduced in the assay muffle, it is impossible to give the terms "hot" and "cool" in degrees of temperature. By the term "hot" is meant a temperature that will keep the slag in the scorifiers thoroughly liquid and will prevent the formation of lead oxide crystals (feathers) in the cupels; by "cool" is meant a temperature that keeps the slag molten but permits the profuse formation of crystals in the cupels. Many other careful assays than those given in Table 8 showed this sample of anode residues to contain 3750 oz. of silver. The table, therefore, proves that from the operations with the higher temperature a considerable portion of the silver was not recoverable; that is, it was volatilized, while at the lower temperature impurities to the extent of 16.22 oz. were retained by the assay beads. Supposing the beads that yielded the result of 3750 oz. to be of 998 fineness, those that gave 3766 oz. should be 993.8 fine. The table shows that in the gold assay of the beads of the latter character considerable gold passes into the decantation liquid, owing to disintegration, and that it is three times as great as that from the beads obtained in the hotter operations and which, therefore, are purer. This decanted gold is not visible, ordinarily, and is not recovered in commercial work. It is best collected by the precipitation of a certain quantity of silver chloride, filtration, etc. There naturally is a gradation in the degree of the gold disintegration from its almost complete cohesion when derived from silver beads of 998 fineness to its pulverulent form when derived from beads of, perhaps, 990 fineness.

A scientific examination of the causes of these differences has not been made. It is a generally accepted theory that the whole silver-gold alloy series form solid solutions in which the two metals are, to a certain extent, in a state of continuity, their molecules remaining within spheres of mutual attraction and therefore the possibility of the cohesive property of the gold when the silver is dissolved. It may readily be imagined that impurities forming eutectic mixtures may be so inter spersed in the alloy as to disrupt the continuity of the gold and to destroy its cohesive property. Or, certain impurities may form chemical compounds with the gold itself, which would no longer have the properties of the metal, but would leave it in a finely divided metallic state upon the action of the nitric acid.

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Microstructure of Iron Deposited by Electric Arc Welding

BY GEORGE F. COMSTOCK,* A. B., MET. E., NIAGARA FALLS, N. Y.

(New York Meeting, February, 1919)

THESE notes should be considered as a further discussion of Mr. S. W. Miller's paper on "Some Structures in Steel Fusion Welds."[1] In that paper and the resulting discussion, several conflicting opinions were expressed as to the identity of the needles or small crystals present in oxyacetylene and electric welds. An interesting specimen of an electric weld examined by the writer seems to afford new evidence regarding the needles, that may be worth presenting at this time. The specimen consisted of a piece of 3/8-in. (9.5-mm.) steel plate, about 2 1/4 by 1 3/4 in. (5.7 by 4.5 cm.) in size, on which some iron had been deposited by arc-welding to a depth of about 3/16 in. (4.7 mm.). The weld appeared to be a very good one, with no noticeable break or boundary between the plate and the deposited iron.

Sections for microscopic examination were cut in three planes at right angles to each other through the deposited metal, two of these sections also extending through the steel base. After polishing in the usual way, the microscope showed that the deposited metal was full of very small, round, gray, oxide spots, while the steel plate contained quite a number of alumina inclusions and a little slag. The sections were etched with nitric acid in ordinary alcohol, and structures similar to those described by Mr. Miller were then displayed. Fig. 1 shows the typical appearance of the deposited metal, which was quite uniform in all three of the planes examined. The round dark-gray spots are oxides, and the pale angular crystals are evidently what Mr. Miller called cementite and Mr. Jeffries martensite, while Dr. Ruder and Prof. Boylston suggested that they might be nitride. The boundary between this structure and the steel base was sharply defined under the microscope. Fig. 2 shows the structure of the plate just under the weld; this is almost martensitic and resembles a coarse-grained casting. This coarse cast structure soon became finer as the distance from the weld increased, finally becoming very fine, with numerous small particles of sorbite. This very fine structure, shown in Fig. 3, became coarser in turn and finally merged into the original normal structure of the steel plate, shown

* Metallographist, Titanium Alloy Manufacturing Co.

[1] *Bulletin* No. 134 (February, 1918), 391; No. 136 (April, 1918), 720; and No. 137 (May, 1918), 1023. Also *Trans.* (1918) **58**, 700–721.

in Fig. 4. Mr. Miller mentioned the coarse structure occurring next to welds, but not the refinement of the original grain farther away, although the latter seems equally characteristic, at least when soft steel is welded.

With a view toward acquiring further information regarding the identity of the pale crystals in the deposited metal, small sections of the sample were cut and one was annealed at 500° C., or below the critical point of the steel, for 2 hr. and cooled in lime. Another was annealed at 900° C., or above the critical point, for 4 hr., and cooled slowly in the furnace. The first annealing did not affect the different zones in the steel plate appreciably but caused the deposited metal, after etching as before with nitric acid, to appear full of darkened needles in place of the pale angular crystals. These needles, shown in Fig. 5, looked somewhat like sorbite deposited along cleavage planes, giving support to the view that the pale crystals might be martensite. The longer annealing above the critical point produced the structure shown in Fig. 6 after the same nitric acid etching. Some needles are still seen here, but most of them seem to have coalesced into pale irregular masses with darkened centers, looking much like the segregated cementite found, as Mr. Miller noted, in annealed low-carbon steel wires and sheets. The coarse and fine zones in the steel plate disappeared after this hotter annealing, and both ferrite and pearlite were coarsened, as shown in Fig. 7. At the boundary between the deposited metal and the steel base, a narrow zone existed, where the needles had invaded the ferrite in the steel without merging with the pearlite that was present. The pearlite stopped abruptly at the upper boundary of this zone, which fact, together with the presence of alumina inclusions in the mixed zone, showed that it was the needles and not the pearlite that had migrated by diffusion. Fig. 8 shows the structure of this narrow zone, with the needles and pearlite present together yet sharply distinct from each other.

This was an unexpected development from the annealing experiments, for if the pale crystals and the needles were cementite, martensite, or some of its decomposition products, they would be expected to merge with the pearlite in the drastically annealed specimen shown in Fig. 8; and if they were nitride, they should disappear according to the German article quoted in my previous discussion.[2] Dr. Ruder, however, stated that the nitride was very hard to remove from steel, so it is probable that the German work was erroneous on this point, and the nitride theory as to the identity of the needles thus appears most plausible. As a further check, the remainder of the original sample submitted was filed so as to remove all the deposited metal with as little contamination as possible from the steel base. These filings, representing metal shown in Fig. 1, were analyzed for carbon by combustion and only 0.04 per cent. of this

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[2] *Bulletin* No. 137 (May, 1918), 1023.

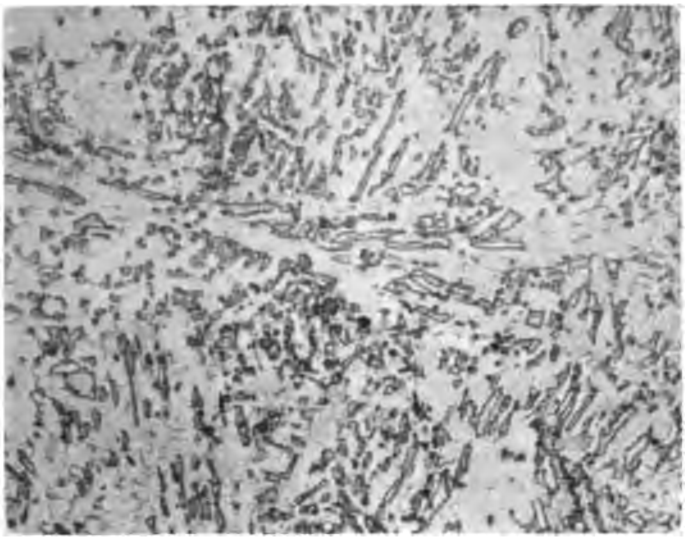

FIG. 1.—DEPOSITED METAL OF WELD BEFORE ANNEALING, ETCHED WITH NITRIC ACID. × 400.

FIG. 2.—STEEL PLATE JUST BELOW WELD, ETCHED WITH NITRIC ACID. × 400.

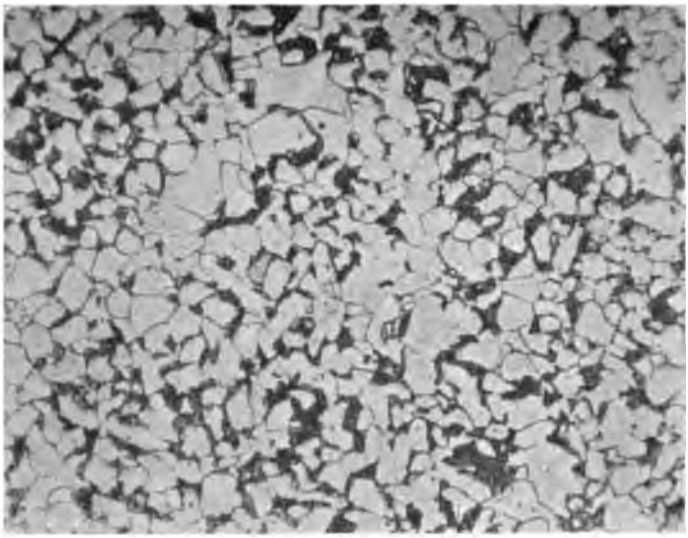

FIG. 3.—STEEL PLATE ABOUT $\frac{3}{16}$ IN. BELOW WELD, ETCHED WITH NITRIC ACID. $\times$ 400.

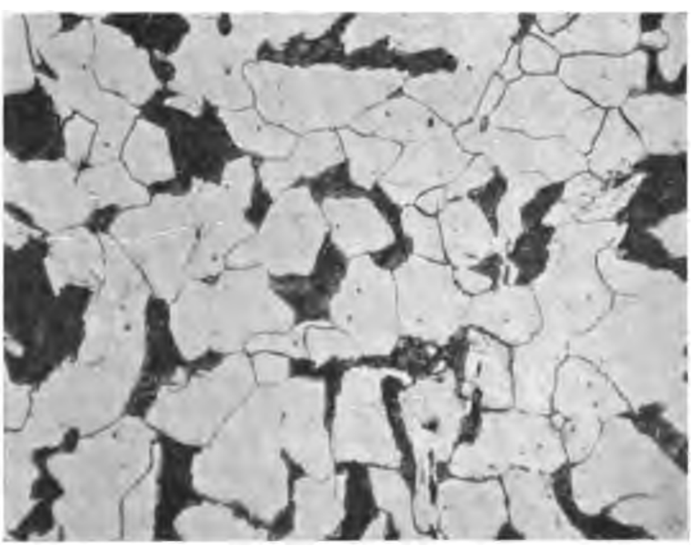

FIG. 4.—STEEL PLATE BEYOND INFLUENCE OF WELD, ETCHED WITH NITRIC ACID. $\times$ 400.

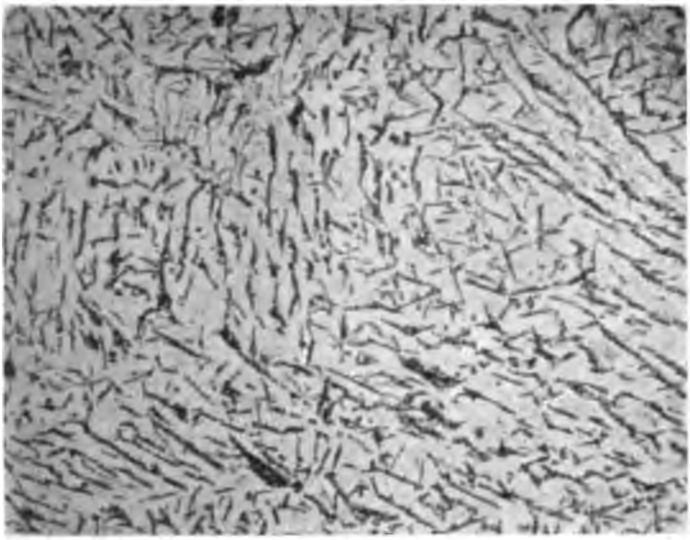

FIG. 5.—DEPOSITED METAL OF WELD AFTER ANNEALING AT 500° C. FOR 2 HR., ETCHED WITH NITRIC ACID. × 400.

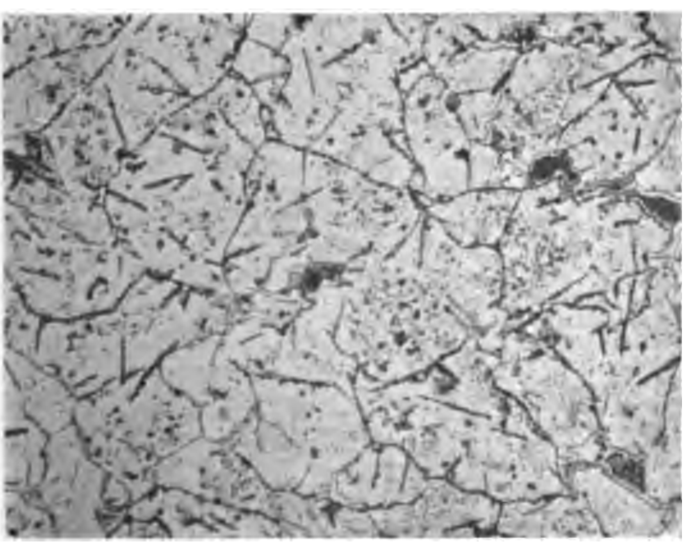

FIG. 6.—DEPOSITED METAL OF WELD AFTER ANNEALING AT 900° C. FOR 4 HR., ETCHED WITH NITRIC ACID. × 400.

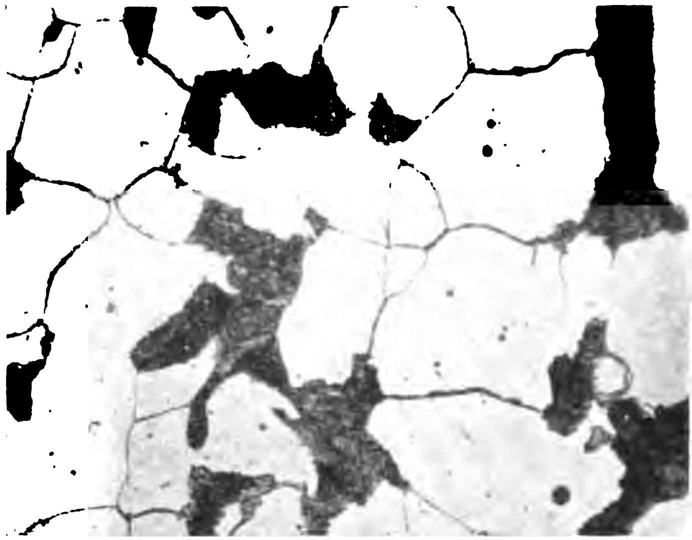

FIG. 7.—STEEL PLATE BELOW ABOUT $\frac{1}{64}$ IN. FROM WELD AFTER ANNEALING AT 900° C. FOR 4 HR., ETCHED WITH NITRIC ACID. × 400.

FIG. 8.—STEEL PLATE JUST BELOW WELD AFTER ANNEALING AT 900° C. FOR 4 HR., ETCHED WITH NITRIC ACID. × 400.

element was found. Certainly, therefore, the pale crystals cannot be cementite, and judging from the amount of decomposition product shown in Fig. 5, more carbon would have to be present if this were all assumed to have come from martensite. It is thus most probable that the pale crystals in Fig. 1, the needles in Figs. 5, 6, and 8, and the pale irregular areas with dark centers in Fig. 6 are all various forms of nitride of iron. Since these structures are all typical of those that Mr. Miller showed, the writer believes that, in most cases at any rate, the structures that he found were due to nitride of iron which assumed various forms according to the speed of cooling after welding. The disappearance of the needles in his annealing experiment agrees with the change shown between Figs. 5 and 6, which were cut from the same specimen containing only 0.04 per cent. carbon, but after different heat-treatments. Of course, these nitride crystals may not always be pure when found in welds and may very likely contain some carbide in solution, but evidently there are cases, such as the one here described, where the crystals or needles are chiefly nitride rather than cementite.

Etching with boiling alkaline sodium picrate was tried on a specimen from the original sample, with the result that the pale crystals were not changed after the usual 10-min. treatment. After boiling for 45 min., however, during which time the solution became more concentrated and the boiling point therefore higher, the crystals were darkened, as shown in Fig. 9. The specimen which had been annealed at 900° C. needed only the usual 10-min. etching to darken its nitride particles, with the result shown in Fig. 10, which should be compared with Fig. 6. This shows that this method of etching darkens not only cementite and sulfide inclusions, but also nitride crystals if continued long enough.

Summarizing, the results of this investigation show that the pale crystals or needles typical of steel fusion welds may occur very abundantly in iron containing only 0.04 per cent. carbon, and that when annealed thoroughly and slowly cooled the needles will diffuse into steel from the welded metal but do not merge with the pearlite of the steel. The conclusion, therefore, is that the pale crystals or needles are not cementite or martensite or any similar carbide product, but most probably nitride of iron. Dr. Ruder's statement that the nitride is not easily removed by heating is corroborated, though the chilling effect of the welding on the steel can be removed easily by annealing. From the above conclusion and the sodium picrate etching tests, it appears further that boiling in this solution will not differentiate between nitride and carbide or sulfide in a polished specimen of steel.

The writer wishes to express his thanks to Mr. E. Wanamaker, electrical engineer of the Rock Island Lines, for the sample investigated, and to Mr. P. Munnoch, chemist of the Titanium Alloy Manufacturing Co., for the chemical analysis.

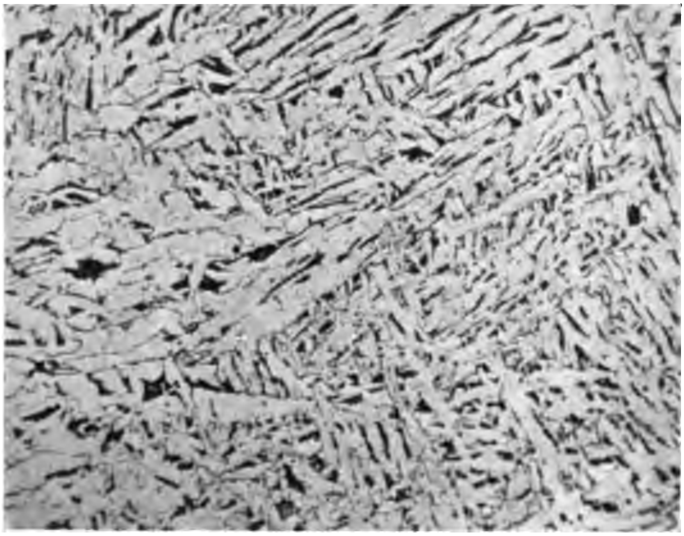

FIG. 9.—DEPOSITED METAL OF WELD BEFORE ANNEALING, BOILED 45 MIN. IN ALKALINE SODIUM PICRATE. × 400.

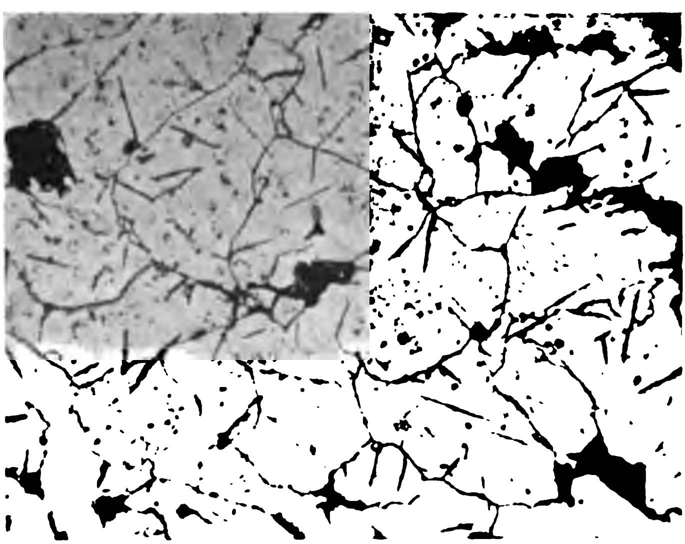

FIG. 10.—DEPOSITED METAL OF WELD AFTER ANNEALING AT 900° C. FOR 4 HR., BOILED 10 MIN. IN ALKALINE SODIUM PICRATE; SAME SPOT SHOWN IN FIG. 6. × 400.

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Development of Grain Boundaries in Heat-treated Alloy Steels

BY R. S. ARCHER,* DETROIT, MICH.

(New York Meeting, February, 1919)

IN the microscopic examination of aircraft-engine parts made of heat-treated alloy steels, the writer has been forcibly impressed by the failure of the usual etching processes to disclose any but gross defects in heat treatment. It seemed particularly desirable to bring out the grain size of the steel, which is indicated in the ordinary etching processes chiefly by the change in orientation of structure from grain to grain. After various attempts, a fairly successful method has been found, which is here presented in the hope that it may be of use to those who have occasion to examine these steels in the heat-treated condition. The specimens worked with have been mostly chrome-nickel steels heat treated (that is, hardened and tempered) to a Brinell hardness of around 300. A few experiments with other specimens will be referred to later.

Briefly, the method employed consists in etching the steel about 10 min. in a fresh solution of picric acid in ethyl alcohol, and then rubbing off the smudge of carbonaceous matter on moist broadcloth. Different samples of almost identical analysis, heat treatment, and physical properties (including resistance to impact) respond quite differently to this treatment. In some, the grain boundaries are developed quite readily, while in others, especially in those whose grain is unusually fine or in which the final hardening heat has not quite obliterated the previous crystallization, the results are more obscure. The exact time of etching to secure the best results also differs for various samples, and the greatest success is usually attained by a process of "tinkering." Such a process is illustrated in a series of micrographs, the first six of which were taken at a magnification of 300 diameters.

The properties of the steel are as follows:

Carbon, per cent	0.420	Brinell hardness	293
Nickel, per cent	1.350	Yield point, pounds per square inch	131,000
Chromium, per cent	0.900	Maximum strength, pounds per square inch	144,500
Copper, per cent	0.025	Elongation in 1 in., per cent	28
Manganese, per cent	0.740	Izod impact, foot-pounds	51
Phosphorus, per cent	0.024	Reduction of area, per cent	57.300
Sulfur, per cent	0.036		

* Bureau of Aircraft Production.

The specimen was etched for 2 min. in a fresh solution of 5 gm. of picric acid in 100 c.c. of denatured alcohol. It was then rubbed gently in all directions on moist kersey cloth, the fine polishing wheel being used for this purpose. Its appearance after this treatment is shown in Fig. 1. The specimen was then etched 2 min. more in the same solution and again wiped on cloth. After photographing, this process was repeated up to a total of 15 min. The results are shown in the micrographs (Figs. 1 to 5), the total time in the etching solution being given below the micrographs.

By this process the clearest development of grain boundaries was obtained at the end of 11 min., the result after 4 min. more of etching being inferior. The sample was then repolished and etched again for 11 min. continuously in a fresh solution. The result was better than before, and is shown in Fig. 6. Fig. 7 shows this structure at a magnification of 1000 diameters. These photographs do not show the same area as is shown in the first series, since the surface layer has been changed in the repolishing. Fig. 8 shows the appearance of the same specimen as etched for 2 min. in the same solution and dried without any rubbing.

With the same specimen of steel, a solution of 5 gm. of picric acid to 100 c.c. of 95 per cent. ethyl alcohol gave results practically identical with those obtained with the solution in denatured alcohol. Absolute alcohol was not tried, nor was any dehydrating agent, such as acetic anhydride. Alcoholic solutions of o-nitro-phenol were found to act too slowly. Mixtures of this reagent with the alcoholic solution of picric acid acted with correspondingly less speed than picric acid, and gave results which were possibly a little more uniform, but not of sufficient improvement to justify the extra time. The same effect might be obtained by diluting the picric-acid solution with alcohol, but this was not tried. The following reagents were tried unsuccessfully: nitric acid in ethyl alcohol, concentrated nitric acid, bromine in alcohol, and bromine in carbon tetrachloride.

A few experiments have been made with other steels and with chrome-nickel steels of different heat treatment. Attempts to develop the grain boundaries in specimens from chrome-nickel gears, made of S.A.E. steel X 3345 and tempered to a Brinell hardness of about 500, failed to give similar results to those obtained with the same steel in a softer condition. A straight carbon steel, of medium carbon content, was quenched in water from 1600° F. (872° C.) and drawn at 1050° F. (566° C.). The grain boundaries could not be brought out by this method. Attempts with a chrome-vanadium steel were at least partly successful. The steel in the shape of ⅝-in. (15.9-mm.) round bars was quenched in water from 1700° F. (922° C.) and drawn at 1050° F., and had the following properties.

FIG. 1.—2 MIN.

FIG 2.—4 MIN.

FIG. 3.—7 MIN.

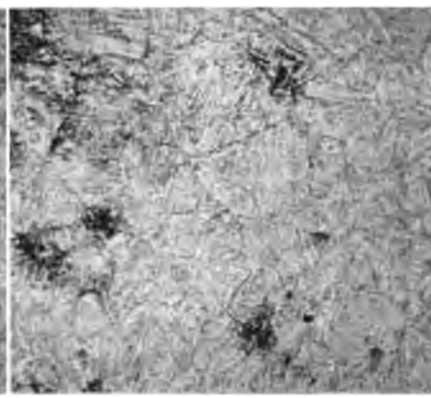

FIG. 4.—9 MIN

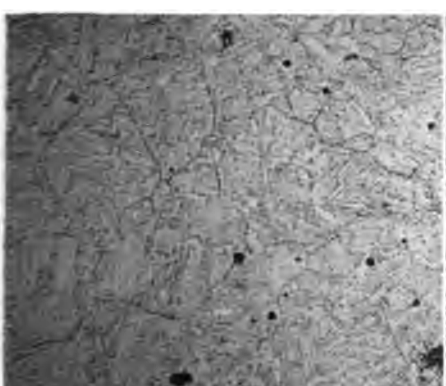

FIG. 5.—11 MIN.

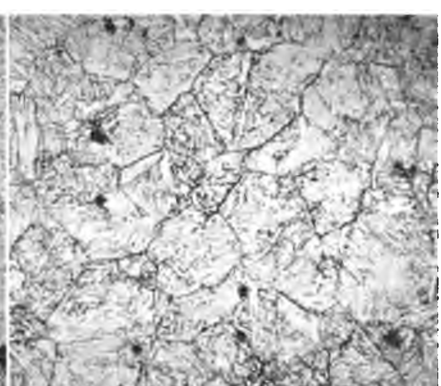

FIG. 6.—11 MIN. CONTINUOUS ETCHING.

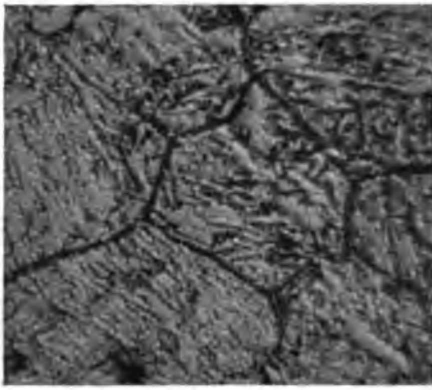

FIG. 7.—SAME AS FIG. 6. × 1000.

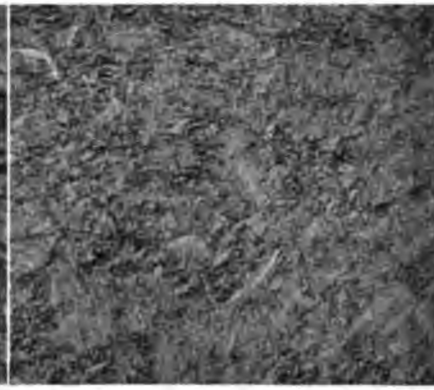

FIG. 8.—ETCHED 2 MIN. WITHOUT RUBBING. × 300.

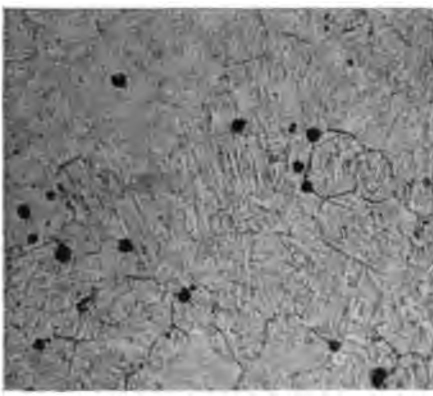

FIG. 9.—CHROME VANADIUM × 300.

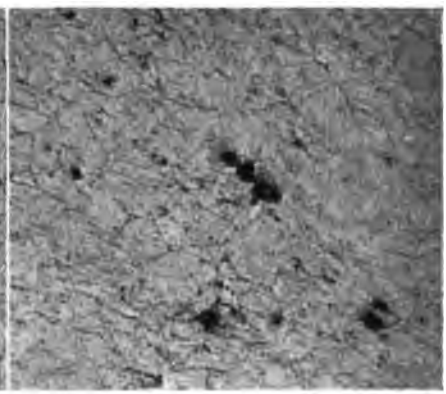

FIG. 10.—CHROME VANADIUM, ETCHED WITHOUT RUBBING. × 300.

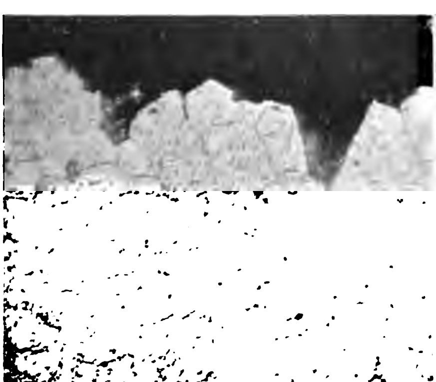

FIG. 11.—PATH OF RUPTURE IN BRITTLE STEEL. × 250.

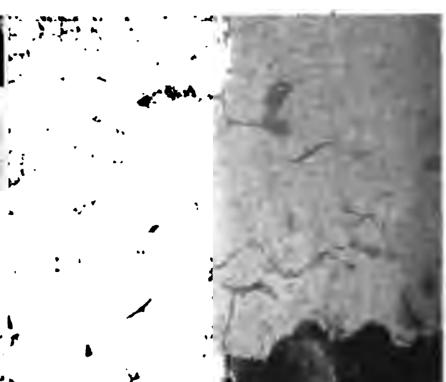

FIG. 12.—INCIPIENT FAILURE IN BRITTLE STEEL. × 250.

Carbon, per cent	0.270	Brinell hardness	302
Chromium, per cent	0.960	Yield point, pounds per square inch	146,000
Vanadium, per cent	0.210	Maximum strength, pounds per square inch	152,100
Manganese, per cent	0.570	Izod impact, foot-pounds	52
Phosphorus, per cent	0.023	Elongation in 2 in., per cent	16.9
Sulfur, per cent	0.031		
Reduction of area, per cent	60.600		

Fig. 9 shows this steel etched 20 min. in picric acid and rubbed, while Fig. 10 shows the result of 2 min. etching without any rubbing. It may be remarked that often a development of grain boundaries can be obtained which makes it possible to get a good idea of grain size by visual examination of various fields of the specimen, but which is not good enough for an accurate grain count in any one area. The grain size is usually such as to render the 4-mm. objective convenient for observation and photography. The writer's brief experience with this method has shown that in some brittle steels the grain outlines are developed more easily than in tough steels of similar analysis and tensile properties.

The method has been tried for tracing the path of rupture in impact test specimens. It works satisfactorily in the case of very brittle steel, where the fracture is shown to take place around the grain boundaries; Fig. 11 shows such a specimen. In Fig. 12, taken from the same specimen, it can be seen that failure has started, in the grain boundaries, below the actual surface of fracture. The properties of this steel were:

Carbon, per cent	0.490	Brinell hardness	302.0
Nickel, per cent	1.900	Izod impact test across grain, foot-pounds	8.5
Chromium, per cent	1.020	Izod impact test parallel to grain, foot-pounds	2.0
Manganese, per cent	0.740		
Sulfur, per cent	0.037		
Phosphorus, per cent	0.037		

When the resistance to impact is high, the fracture is through the grains. The resulting deformation of the grains causes failure of the etching process to bring out the grain boundaries near the fracture. The manner of failure, however, is readily apparent from the profile of the fracture.

Summary

A method of etching is described which has been found useful in bringing out the grain boundaries of chrome-nickel and chrome-vanadium steels hardened and tempered to a Brinell hardness around 300. This method consists in etching the specimen in a 4 per cent. solution of picric acid in ethyl alcohol for a period varying from 5 to 25 min., and then rubbing off the carbonaceous smudge on moist broadcloth or kersey.

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A Comparison of Grain-size Measurements and Brinell Hardness of Cartridge Brass

BY W. H. BASSETT* AND C. H. DAVIS,† WATERBURY, CONN.

(New York Meeting, February, 1919)

In the commercial annealing of cartridge brass there are four points regarding which definite data are essential. They have to do with the correct interpretation of grain count in its relation to annealing temperature and, incidentally, to Brinell hardness. These points are:

1. The comparison of the grain sizes of two cartridge-brass mixtures: 69 copper, 31 zinc, 0.376-in. (9.5-mm.) gage; and 68 copper, 32 zinc, 0.130-in. (3.3-mm.) gage.

2. The comparison of the grain sizes of annealed metal that had previously been reduced by rolling varying amounts; for instance, 20.0, 36.6, 50.9, and 59.1 per cent.

3. The determination of standards for grain sizes on annealed brass of the composition 68 per cent. copper, 32 per cent. zinc and 69 copper, 31 zinc.

4. The comparison of grain size with Brinell hardness on identical samples of annealed metal.

In their comprehensive and thorough investigation of the recrystallization of cold-worked alpha brass on annealing,[1] Mathewson and Phillips have discussed the relations between temperature of anneal, degree of deformation, and structural alteration in alpha brass. They have also shown certain comparisons between the ordinary physical properties and the grain size of annealed brass. The purpose of the present investigation is mainly concerned with the grain size of cartridge brass, its relation to Brinell hardness, and the publication of sufficient data to enable those engaged in the inspection of such material to have a correct foundation upon which to work.

The first alloy was taken from regular mill stock that had been rolled from 0.580 in. to 0.376 in. (14.7 mm. to 9.5 mm.) gage, a reduction of 35.1 per cent. This bar (No. 1) had the following composition: Copper, 69.20 per cent.; zinc, 30.76 per cent.; lead, 0.02 per cent.; iron, 0.02 per cent.

The second alloy was also taken from mill stock of 0.325 in. (8.25 mm.) gage and was rolled as shown in Table 1, in order to get four bars reduced

* American Brass Co. † American Brass Co. [1] *Trans.* (1916) **54**, 608–657.

two, four, six, and eight B. & S. numbers respectively. This second alloy had the composition: Copper, 68.48 per cent.; zinc, 31.47 per cent.; lead, 0.02 per cent.; iron, 0.03 per cent.

TABLE 1.—*Results Obtained by Rolling Bars*

Bar No.	Annealed Bar Selected from Stock, Inch	Rolled to, Inch	Annealed on, Inch	Rolled to, Inch	Reduction by Rolling, Per Cent.
2	0.325	.....	0.325	0.133	59.1
3	0.325	0.273	0.273	0.134	50.9
4	0.325	0.213	0.213	0.135	36.6
5	0.325	0.168	0.168	0.134	20.2

Specimens, 1 by 3 in. (25.4 by 76.2 mm.), from each of these five bars were annealed for ½ hr. at 50° C. intervals, from 200° C. to 850° C. From 275° C. to 425° C., additional samples were annealed at 25° C. intervals. The specimens were tightly wrapped together in sheet copper and were quenched with their covering as quickly as possible at the end of ½ hr. at the required temperature. A new Bristol indicator and recorder with base-metal couple was used, the latter being wrapped with the specimens. The couple was checked and calibrated before and after annealing by the boiling point of sulfur and the melting point of sodium chloride.

The Brinell hardness tests were made with an Aktiebolaget alpha machine. A load of 500 kg. and the standard 10-mm. diameter ball were used and the pressure maintained for 30 sec. The pressure exerted by this machine was checked by weighing on a standard scale. The surfaces of both hard and annealed specimens were scoured with emery cloth and polished with fine emery before testing. Two impressions were taken, one in the center of the specimen and the other halfway toward the end. Readings of these were made upon an 80 mm. Gaertner comparator, accurate to 0.001 mm. One reading was taken in the direction of the original rolling, the other at right angles to that direction for each impression, and the four results averaged. Little or no discrepancy was found in these results, except in the case of the hard-rolled specimens where the impression was oblong, the longer diameter coinciding in direction with the direction of rolling. In the harder samples this difference in diameter was equivalent to as much as 10 Brinell points.

The grain size was counted on a section taken parallel to the surface between the two Brinell impressions. On the specimens annealed below 700° C. the magnification used was 150 diameters; at 700° C., 75 diameters; and from 750° C. to 850° C., 50 diameters. The method of counting used is recommended by the American Society for Testing Materials.[2]

[2] Tentative Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys. *Proc.* Am. Soc. for Test. Mat. (1917) **17**, Pt. 1, 838.

It is also described by Zay Jeffries and others.[3] A circle 79.8 mm. in diameter was used in counting and the diameter of the average grain in millimeters was determined. The following formulas, proposed by Prof. Jeffries, were used:

w = boundary grains;
z = completely included grains;
x = equivalent number of whole grains in 5000 sq. mm. (circle 79.8 mm. diameter or rectangle having area of 5000 sq. mm.);
m = magnification used;
f = multiplier to obtain grains per square millimeter;
n = number of grains per square millimeter;
d = diameter of average grain in millimeters;
a = area of average grain in U^2.

$$x = \tfrac{1}{2} w + z \qquad f = \frac{m^2}{5000} \qquad n = fx$$

$$d = \frac{1}{\sqrt{n}} \qquad a = \frac{1{,}000{,}000}{n}$$

Tables 2, 3, and 4 give a résumé of the results obtained.

TABLE 2.—*Brinell Hardness and Grain Size on* 69-31 *Brass*
(See Fig. 2)

Bar No. 1. Rolled from 0.580 in. to 0.376 in. (14.7 mm. to 9.5 mm.). Reduction by rolling 35.1 per cent. (4—B. & S. numbers. Hard)

Anneal. Temp., Degrees C.	x	Mag. Dia.	f	n	$\sqrt{n}$	d	Av. d	Av. Brinell Number from Two Imp. and Four Readings
850	10.0	50	0.5	5.0	2.23	0.448	.....	41.3
800	24.0	50	0.5	12.0	3.4	0.3	.....	43.9
750	52.5	50 75	0.5 1.125	26.2	5.1	0.198 0.196	0.197	46.0
700	73.0	75	1.125	82.12	9.06	0.110	0.110	50.6
650	64.5	150 75	4.5 1.125	290.25	17.03	0.0587 0.0667	0.062	55.8
600	127.0	150 75	4.5 1.125	571.5	23.90	0.0464 0.0418	0.044	61.7
550	226.0	150 75	4.5 1.125	1017.0	31.89	0.0381 0.0313	0.033	65.9
500	449.0 368.0	150	4.5	2020.5 1656.0	44.95 40.6	0.0222 0.024	0.023	70.4
450	617.0 531.0	150	4.5	2776.5 2389.5	52.69 48.8	0.0190 0.020	0.020	75.0
425	.....	...	.....	......	.....	......	.....	75.2
400				Uniformly annealed.				82.6
375	.....	...	....	......	.....	......	.....	88.3
350				Ninety-five per cent. new grains.				102.0
325	.....	...	....	......	.....	......	.....	102.0
300				Few new grains.				143.0
275				No new grains.				153.0
250				No new grains.				153.0
200				No new grains.				153.0
Hard....	.....	...	....	......	.....	......	.....	146.0

[3] *Trans.* (1916) **54**, 594–607. Elaborated in *Met. and Chem. Engng.* (Feb. 15, 1918) **8**, 185.

TABLE 3.—*Brinell Hardness and Grain Size on* 68-32 *Brass*
(See Figs. 1 and 3)

Bar No. 2 (Mark ●). Reduction by rolling 20.2 per cent.
(2—B. & S. numbers)

Anneal. Temp., Degrees C.	x	Mag. Dia.	f	n	$\sqrt{n}$	d	Av. Brinell Number from Two Imp. and Four Readings
850	15.0	50	0.5	7.5	2.74	0.365	41.7
800	32.5	50	0.5	16.25	4.03	0.247	43.6
750	57.5	50	0.5	28.75	5.36	0.186	45.7
700	71.0 •	75	1.125	79.875	8.93	0.112	49.0
650	42.5	150	4.5	191.25	13.82	0.072	52.0
600	62.0	150	4.5	279.0	16.70	0.059+	56.1
550	87.0	150	4.5	391.5	19.7	0.0507	58.2
500	110.0±	150	4.5	495.0	22.2	0.045	60.5
450	118.5	150	4.5	533.25	23.09	0.043	65.5
425	.....	...	.....	....	.....	....	69.1
400	One-fourth area consists of new grains.						89.7
375	Few new grains.						94.1
350	No new grains.						101.0
325	No new grains.						100.0
300	No new grains.						103.0
275	......	...	.....	....	.....	....	104.0
250	......	....	.....	....	.....	....	106.0
200	......	...	.....	....	......	....	109.0
Hard....	......	...	.....	....	......	....	110.0

Bar No. 3 (Mark +). Reduction by rolling 36.6 per cent.
(4—B. & S. numbers)

Anneal. Temp., Degrees C.	x	Mag. Dia.	f	n	$\sqrt{n}$	d	Av. Brinell Number from Two Imp. and Four Readings
850	17.0	50	0.5	8.5	2.91	0.344	41.1
800	44.0	50	0.5	22.0	4.69	0.213	43.1
750	71.5	50	0.5	35.75	5.97	0.167	45.9
700	52.0	75	1.125	58.50	7.65	0.131	48.9
650	34.5	150	4.5	155.25	12.46	0.080	51.5
600	83.0	150	4.5	373.5	19.30	0.0518	55.4
550	142.5	150	4.5	641.25	25.32	0.0395	61.3
500	196.0	150	4.5	882.0	29.70	0.034	66.4
450	198.0	150	4.5	891.0	29.85	0.0336	70.5
425	......	...	.....	....	.....	....	71.2
400	Completely recrystallized.						74.6
375	......	...	.....	....	......	....	88.8
350	One-third area consists of new grains.						100.0
325	Some new grains.						106.0
300	No new grains.						137.0
275	No new grains.						140.0
250	No new grains.						143.0
200	No new grains.						148.0
Hard....	.....	...	.....	....	......	....	147.0, 136.0 } 142

TABLE 4.—*Brinell Hardness and Grain Size on* 68-32 *Brass*
(See Figs. 1 and 3)

Bar No. 4 (Mark ×). Reduction by rolling 50.9 per cent.
(6 + B. & S. numbers)

Anneal. Temp., Degrees C.	x	Mag. Dia.	f	n	$\sqrt{h}$	d	Av. Brinell Number from Two Imp. and Four Readings	
850	18.5	50	0.5	9.25	3.04	0.329	42.0	
800	38.0	50	0.5	19.0	4.35	0.230	43.1	
750	67.5	50	0.5	33.75	5.80	0.172	46.4	
700	68.0	75	1.125	76.50	8.75	0.114	49.7	
650	38.0	150	4.5	171.0	13.07	0.076	52.1	
600	84.0	150	4.5	378.0	19.43	0.0515	56.8	
550	165.5	150	4.5	744.75	27.28	0.0366	62.0	
500	177.0	150	4.5	796.5	28.20	0.0355	69.1	
450	446.0+	150	4.5	2007.0	44.8	0.022	74.1	
425	....	...	.....	....	.....	......	76.5	
400			Completely recrystallized.				79.6	
375	....	...	.....	....	.....	......	86.4	
350			Few remnants of former crystals.				91.2	
325	....	...	.....	....	.....	......	93.3	
300			One-fourth area consists of new grains.				130.0	
275			Few new grains.				155.0	
250			No new grains.				166.0	
200			No new grains.				169.0	
Hard....	....	...	.....	....	.....	......	163.0 153.0	158

Bar No. 5 (Mark ○). Reduction by rolling 59.1 per cent.
(8 − B. & S. numbers)

Anneal. Temp., Degrees C.	x	Mag. Dia.	f	n	$\sqrt{h}$	d	Av. Brinell Number from Two Imp. and Four Readings	
850	16.0	50	0.5	8.0	2.83	0.353	41.7	
800	36.5	50	0.5	18.25	4.27	0.234	44.1	
750	77.0	50	0.5	38.5	6.50	0.161	46.4	
700	66.0	75	1.125	74.25	8.62	0.116	49.2	
650	38.5	150	4.5	173.25	13.17	0.076	52.4	
600	78.0	150	4.5	351.0	18.73	0.0534	57.2	
550	175.5	150	4.5	789.75	28.1	0.0356	62.0	
500	314.5	150	4.5	1415.25	37.5	0.0266	69.1	
450	400.0	150	4.5	1800.0	42.4	0.0236	77.4	
425	....	...	.....	....	.....	......	79.0	
400			Completely recrystallized				83.8	
375	....	...	.....	....	.....	......	88.6	
350			Completely recrystallized.				91.9	
325	....	...	.....	....	.....	......	93.3	
300			One-half to six-tenths new grains.				124.0	
275			Few new grains.				154.0	
250			No new grains.				171.0	
200	....	...	.....	....	.....	......	172.0	
Hard...	....	...	.....	....	.....	......	168.0 158.0	163

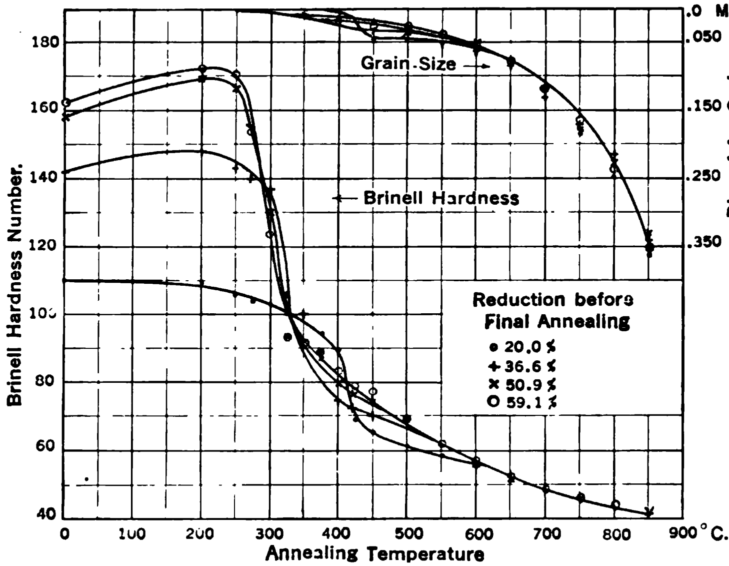


FIG. 1.—DIRECT COMPARISON OF BRINELL AND GRAIN-SIZE MEASUREMENTS ON 0.130-IN. GAGE CARTRIDGE BRASS. ANNEALED ½ HR. AT TEMPERATURES NOTED. SPECIMENS WERE PREVIOUSLY REDUCED BY ROLLING AS INDICATED.

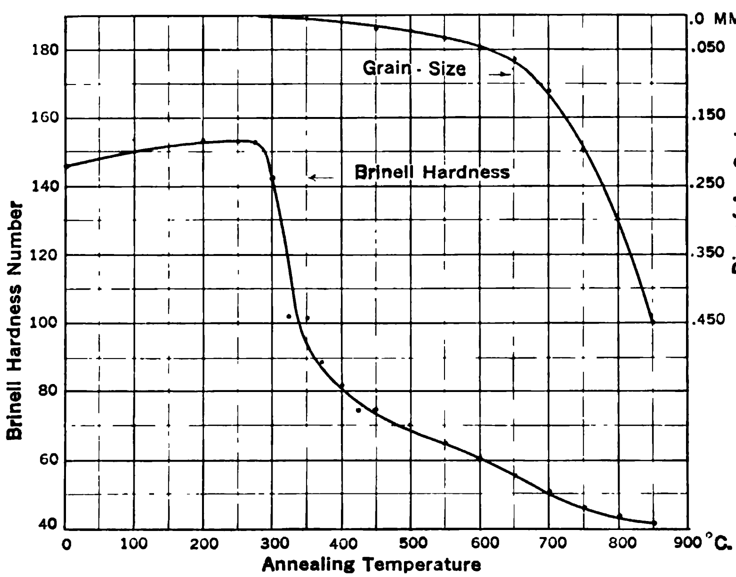


FIG. 2.—DIRECT COMPARISON OF BRINELL AND GRAIN-SIZE MEASUREMENTS ON 0.376-IN. GAGE CARTRIDGE BRASS. ANNEALED ½ HR. AT TEMPERATURES NOTED SPECIMENS WERE PREVIOUSLY REDUCED 35.1 PER CENT. BY ROLLING.

The micrographs taken to illustrate this paper are magnified 75 diameters but the grain counts were made on micrographs taken in the same area but magnified 50, 75, or 150 diameters. Accompanying this report are three plots. The first, Fig. 1, shows the relation of Brinell hardness to annealing temperature and the relation of grain size to annealing temperature for the 68-32 alloy; the second, Fig. 2, shows the same relations for the 69-31 alloy, the third, Fig. 3, shows the relation of Brinell hardness to grain size for a given alloy of copper and zinc.

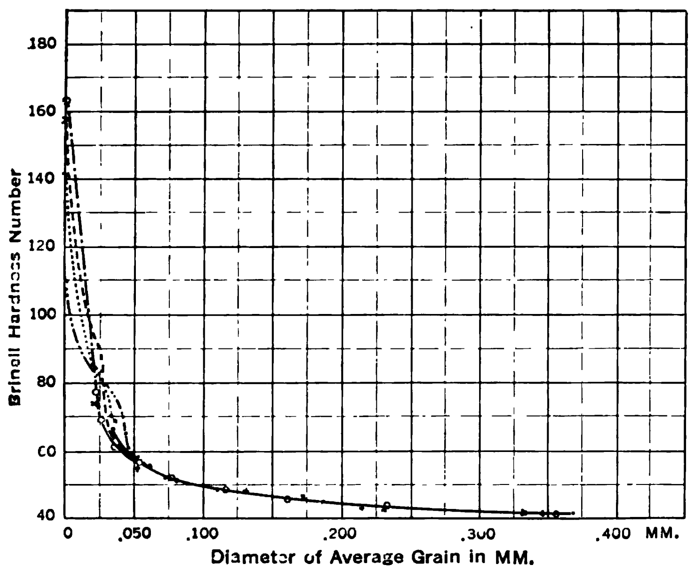


FIG. 3.—BRINELL HARDNESS INDICATES GRAIN SIZE FOR ANY GIVEN BRASS IN THE ALPHA PHASE. AT LOW TEMPERATURES THE GRAIN SIZE IS INFLUENCED BY THE GRAIN SIZE OF THE PREVIOUS ANNEAL, 650° C. IN THIS CASE. PLOTTED FROM THE DATA USED FOR FIG. 1.

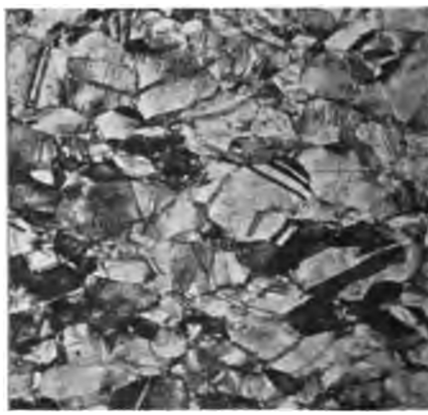
The Brinell method is a very accurate way of determining the hardness of sheet brass. The hardness of rolled metal is relatively proportionate to the percentage reduction by rolling.[4] The hardness of annealed metal is relatively proportionate to the temperature of annealing[5] (for any fixed period of time). The Brinell hardness of annealed metal is proportionate to the annealing temperature, but this proportion varies on account of two factors; namely, the amount of the last rolling the metal received, and the grain size that existed at the time of that rolling. Figs. 1 and 4 to 13 illustrate these points in the case of the 0.130-in. (3.3-mm.) gage cartridge brass and show: that in annealing hard-

[4] C. H. Davis: Testing of Sheet Brass. *Proc.* Am. Soc. Test. Mat. (1917), **17**, Pt. 2, 166.

[5] C. H. Davis: *Op cit.*, Fig. 8 and Fig. 3.

20.2 PER CENT. REDUCTION | 36.6 PER CENT. REDUCTION

BRIN. 110 | AS ROLLED | BRIN. 142

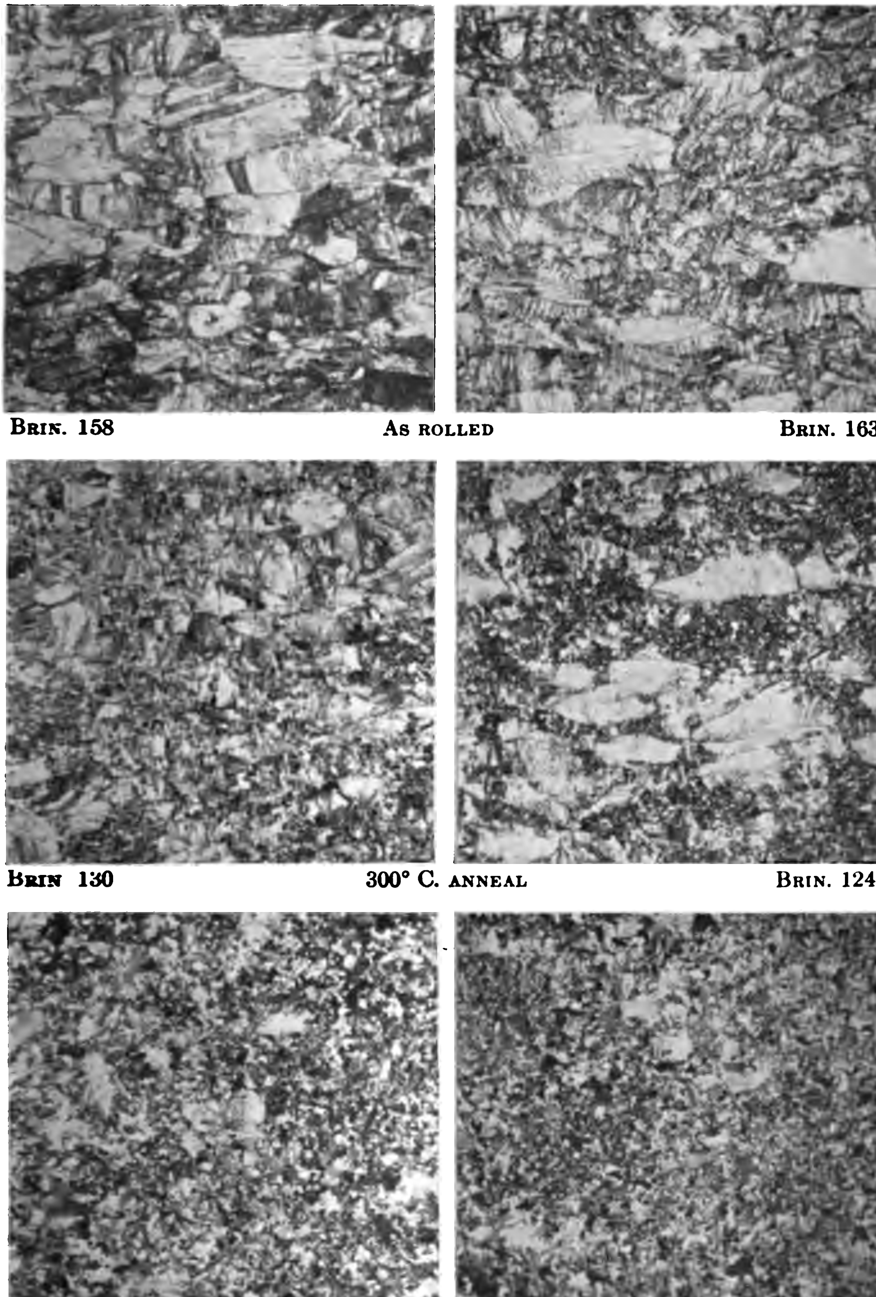


BRIN. 103 | 300° C. ANNEAL | BRIN. 137

BRIN. 100 | 325° C. ANNEAL | BRIN. 106

FIG. 4.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. × 75.

50.9 PER CENT. REDUCTION 59.1 PER CENT REDUCTION



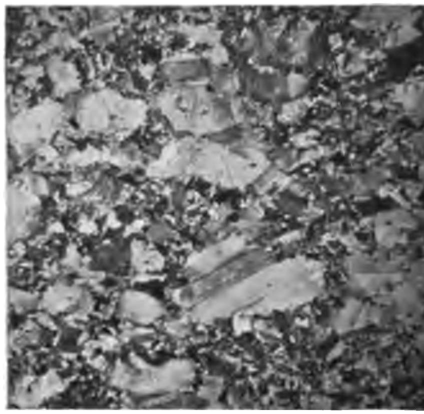
BRIN. 158 AS ROLLED BRIN. 163

BRIN 130 300° C. ANNEAL BRIN. 124

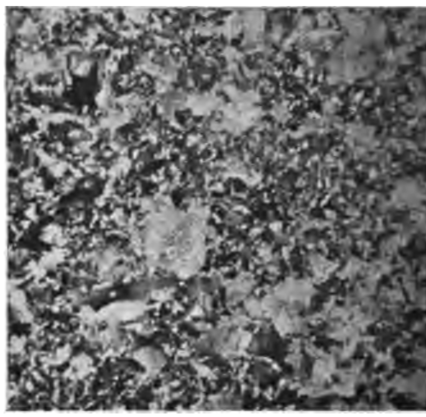
BRIN. 93.3 325° C. ANNEAL BRIN. 93.3

FIG. 5.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. × 75.

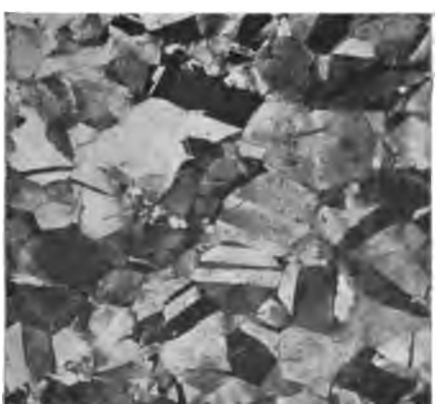
20.2 PER CENT. REDUCTION | 36.6 PER CENT. REDUCTION

BRIN. 101 | 350° C. ANNEAL | BRIN. 100

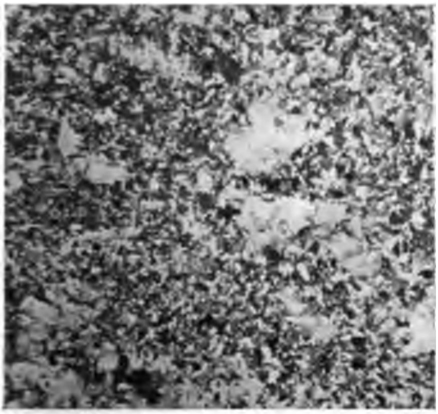
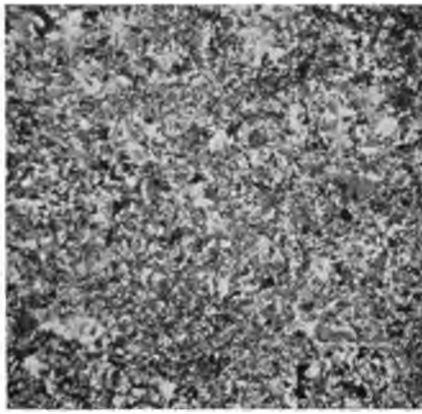
BRIN. 94.1 | 375° C. ANNEAL | BRIN. 88.8



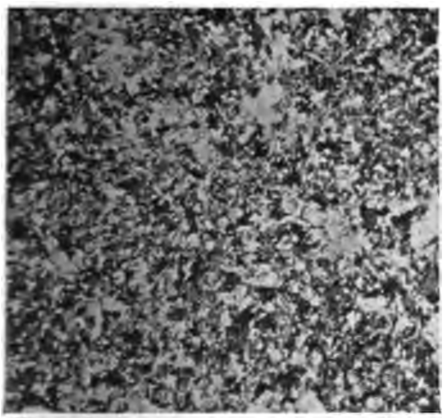
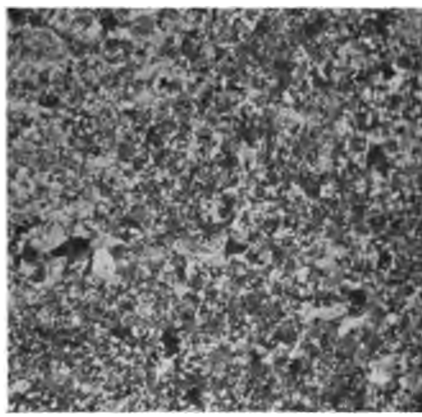

BRIN. 89.7 | 400° C. ANNEAL | BRIN. 74.6

FIG. 6.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. × 75.

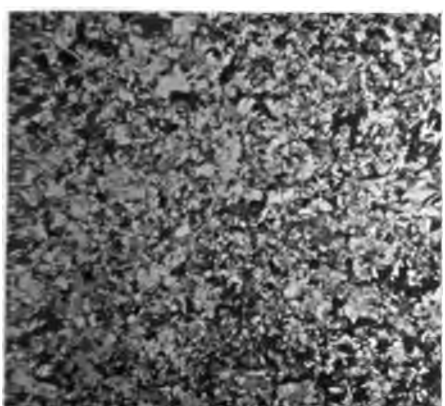
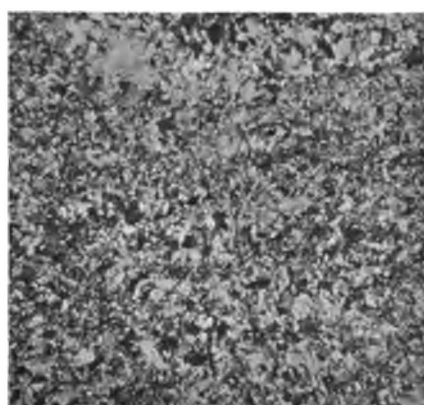
50.9 PER CENT. REDUCTION | 59.1 PER CENT. REDUCTION

BRIN. 91.2 | 350° C. ANNEAL | BRIN. 91.9

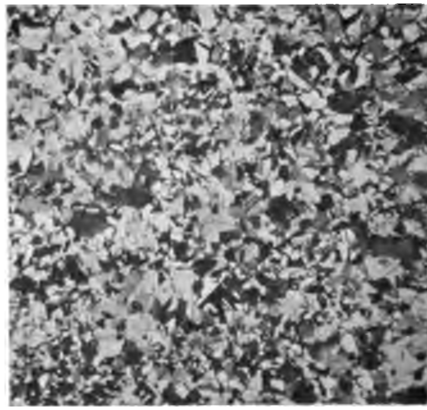
BRIN. 86.4 | 375° C. ANNEAL | BRIN. 88.6

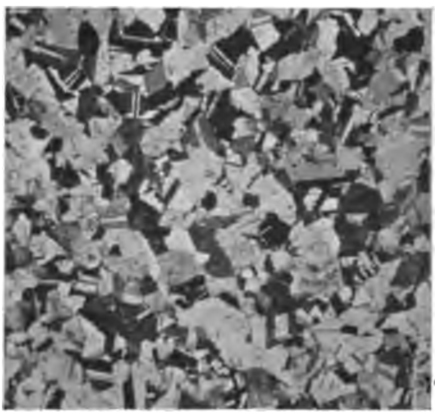
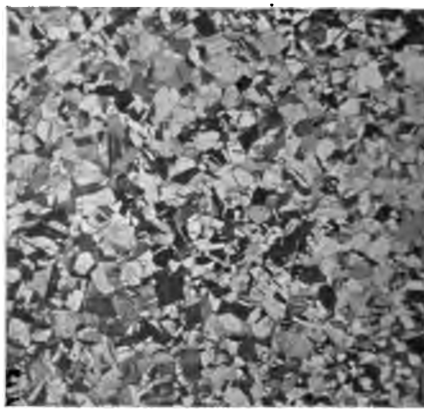
BRIN. 79.6 | 400° C. ANNEAL | BRIN. 83.8

FIG. 7.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. × 75.

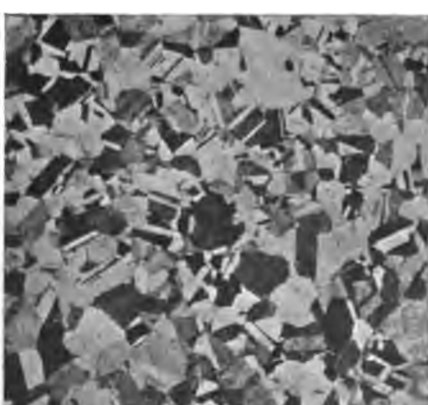
20.2 PER CENT. REDUCTION | 36.6 PER CENT. REDUCTION

BRIN. 65.5, $d = 0.043$ MM. 450° C. ANNEAL BRIN. 70.5, $d = 0.0336$ MM.

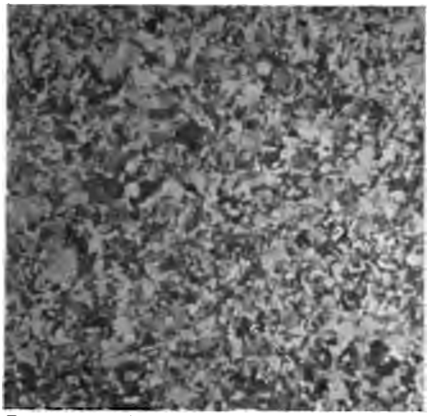
BRIN. 60.5, $d = 0.045$ MM. 500° C. ANNEAL BRIN. 66.4, $d = 0.034$ MM.

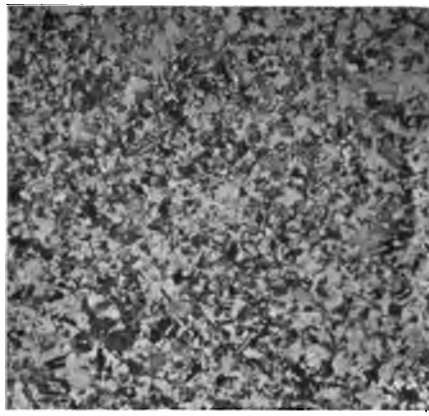



BRIN. 58.2, $d = 0.0507$ MM. 550° C. ANNEAL BRIN. 61.3 $d = 0.0395$ MM.

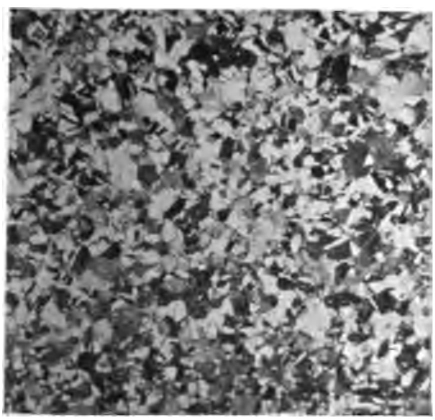
FIG. 8.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. × 75.

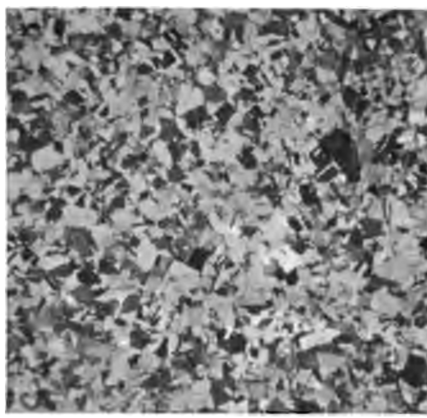
50.9 PER CENT. REDUCTION | 59.1 PER CENT. REDUCTION



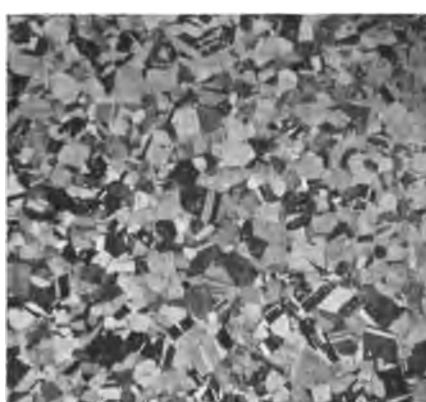


BRIN. 74.1, $d = 0.022$ MM. 450° C. ANNEAL BRIN. 77.4, $d = 0.0236$ MM.





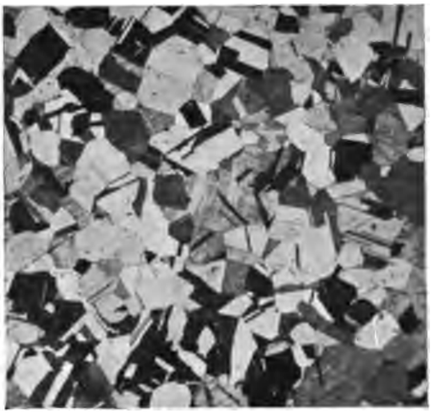
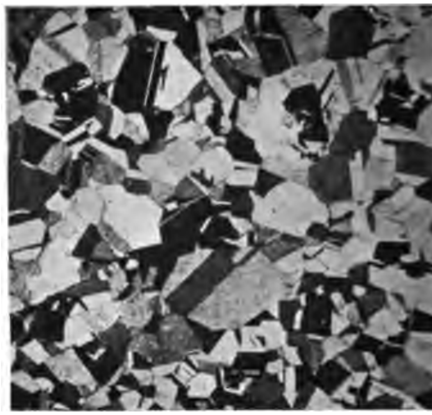
BRIN. 69.1, $d = 0.0355$ MM. 500° C. ANNEAL BRIN. 69.1, $d = 0.0266$ MM.



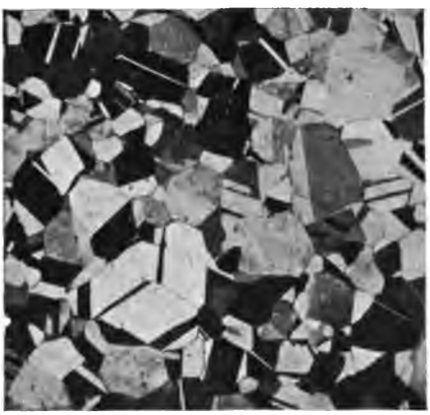
BRIN. 62.0, $d = 0.0366$ MM. 550° C. ANNEAL BRIN. 62.0, $d = 0.0356$ MM.

FIG. 9.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. × 75.

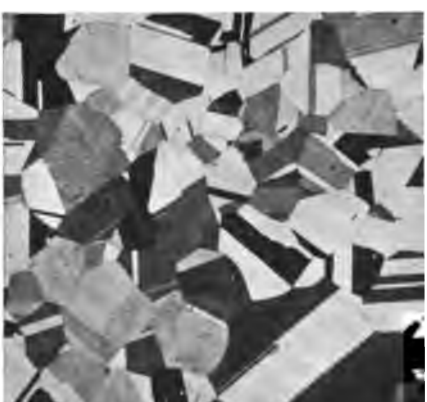
20.2 PER CENT. REDUCTION | 36.6 PER CENT. REDUCTION

BRIN. 56.1, $d = 0.059$ MM. 600° C. ANNEAL BRIN. 55.4 $d = 0.0518$ MM.




BRIN. 52.0, $d = 0.072$ MM. 650° C. ANNEAL BRIN. 51.5, $d = 0.080$ MM.

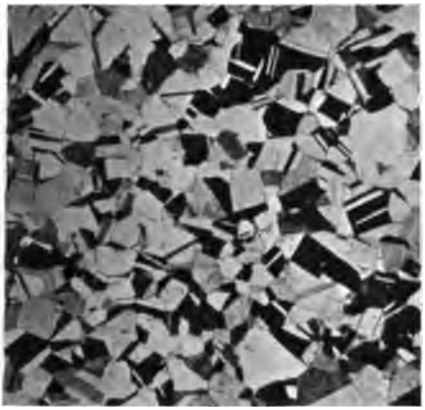


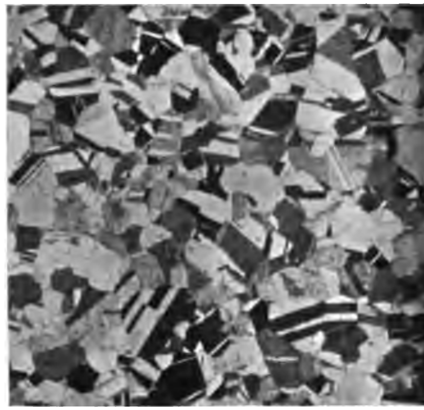

BRIN. 49.0, $d = 0.112$ MM. 700° C. ANNEAL BRIN. 48.9, $d = 0.131$ MM.

FIG. 10.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. × 75.

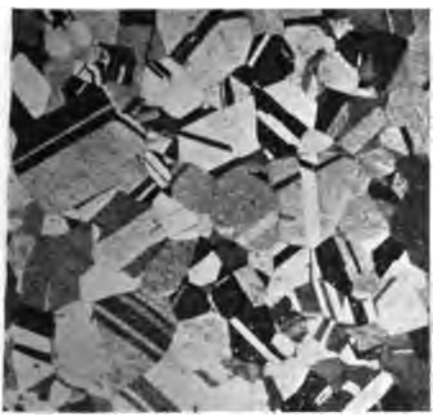
50.9 PER CENT. REDUCTION

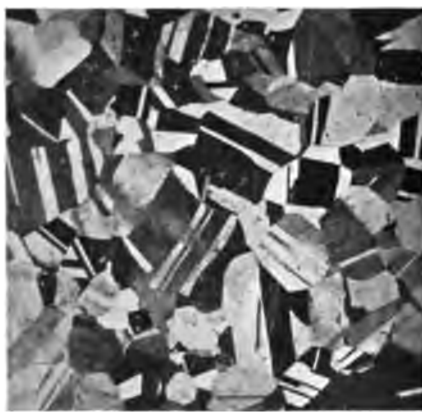
59.1 PER CENT. REDUCTION





BRIN. 56.8, $d = 0.0515$ MM. 600° C. ANNEAL BRIN. 57.2, $d = 0.0534$ MM.



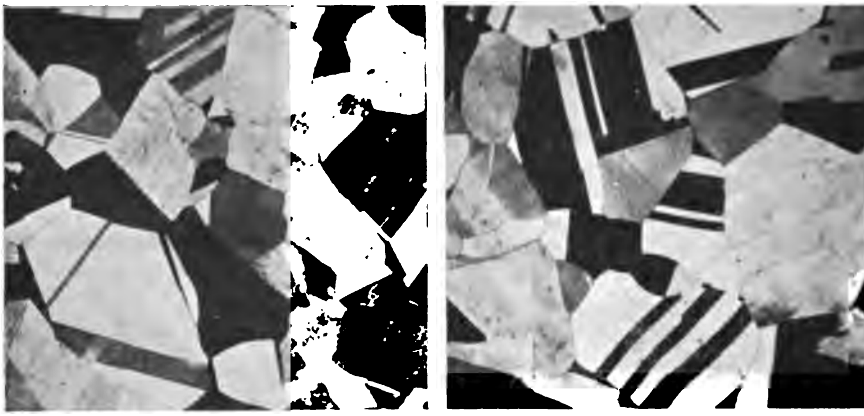


BRIN. 52.1. $d = 0.076$ MM. 650° C. ANNEAL BRIN. 52.4, $d = 0.076$ MM

BRIN. 49.7, $d = 0.114$ MM 700° C. ANNEAL BRIN. 49.2, $d = 0.116$ MM.

FIG. 11.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. $\times$ 75.

20.2 PER CENT. REDUCTION 36.6 PER CENT. REDUCTION



BRIN. 45.7, $d = 0.186$ MM. 750° C. ANNEAL BRIN. 45.9, $d = 0.167$ MM.

BRIN. 43.6, $d = 0.247$ MM. 800° C ANNEAL BRIN 43.1, $d = 0.213$ MM.

BRIN. 41.7, $d = 0.365$ MM. 850° C. ANNEAL BRIN. 41.1, $d = 0.344$ MM.

FIG. 12.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. × 75.

50.9 PER CENT. REDUCTION — 59.1 PER CENT. REDUCTION

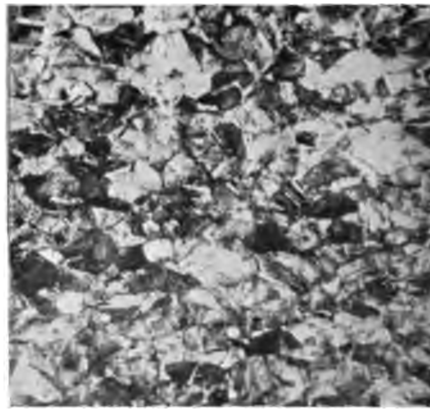
BRIN. 46.4, $d = 0.172$ MM — 750° C. ANNEAL — BRIN. 46.4, $d = 0.161$ MM.

BRIN. 43.1, $d = 0.230$ MM. — 800° C. ANNEAL — BRIN. 4[illegible].1, $d = 0.234$ MM.

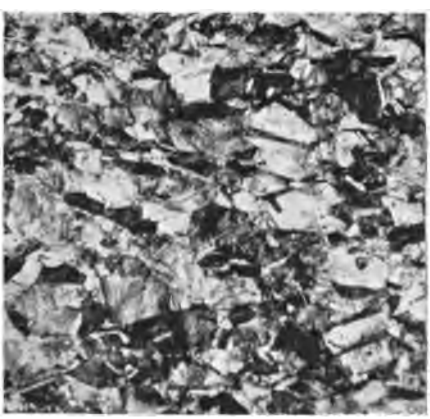
BRIN. 42.0, $d = 0.329$ MM. — 850° C. ANNEAL — BRIN. 41.7, $d = 0.353$ MM.

FIG. 13.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. $\times 75$.

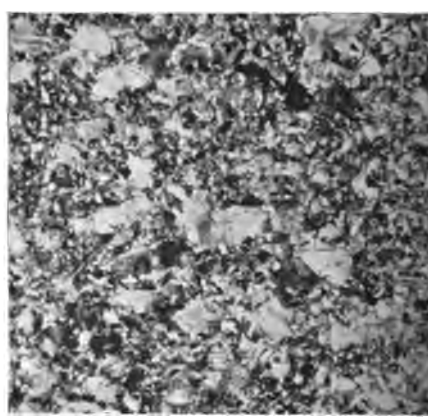
Brin. 146—As rolled



Brin. 153—250° C.

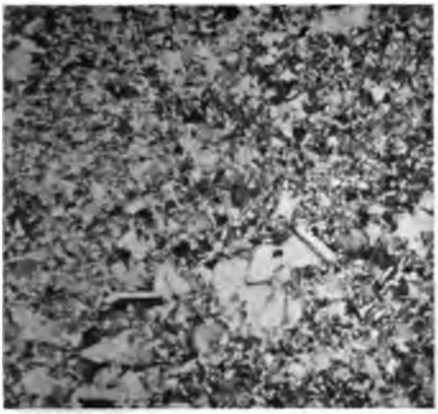


Brin. 143—300° C.

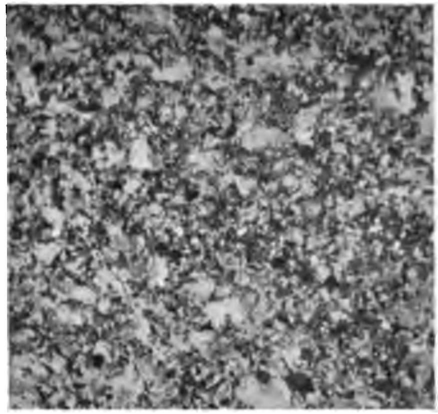


Brin. 102—325° C.

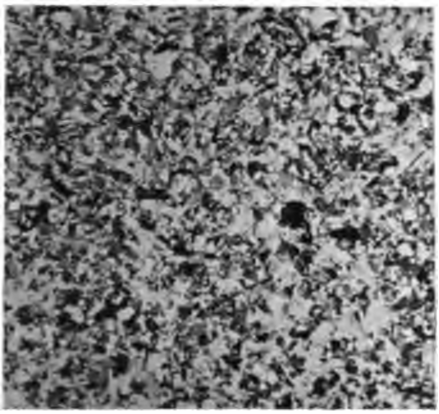
Fig. 14.—Etched with ammonia and hydrogen peroxide. × 75.



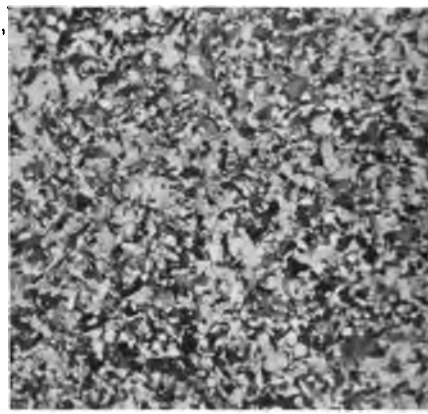
BRIN. 102—350° C.



BRIN. 88.3—375° C.



BRIN. 82.6—400° C.



450° C.
BRIN. 75, $d = 0.020$ MM.

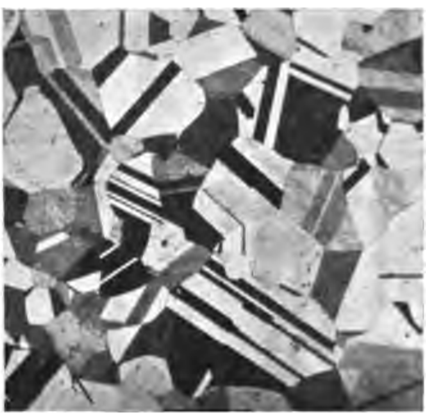
500° C.
BRIN. 70.4. $d = 0.023$ MM.

550° C.
BRIN. 65.9, $d = 0.033$ MM.

FIG. 15.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. × 75.

600° C.
Brin. 61.7, $d = 0.044$ mm.

650° C.
Brin. 55.8, $d = 0.062$ mm.



700° C.
Brin. 50.6, $d = 0.110$ mm.

750° C.
Brin. 46.0, $d = 0.197$ mm.

800° C.
Brin. 43.9, $d = 0.300$ mm.

850° C.
Brin. 41.3, $d = 0.448$ mm.

Fig. 16.—Etched with ammonia and hydrogen peroxide. × 75.

rolled metal the drop in Brinell hardness indicates softening of the metal just before the new grains are seen; that the softening of lightly rolled metal progresses considerably before any new crystals can be detected; that the Brinell hardness of all specimens agrees closely from 600° C. to 850° C. As the previous anneal of the original hard specimens was about 650° C., the conclusion is drawn, and borne out by experience, that both the Brinell hardness and the grain size of annealed metal are greatly affected by the grain size due to the anneal previous to the anneal under discussion; and, as the grain size of the previous anneal diminishes, the Brinell hardness curves and the grain-size curves will approach those of metal annealed after very hard rolling as a limit; *i.e.*, in Fig. 1, the curve marked 59.1 per cent. reduction is this limit for the curves that represent more lightly rolled material. Figs. 14 to 16 illustrate the grain-size of 0.376-in. gage cartridge brass containing 69.20 per cent. copper, 30.76 per cent. zinc, 0.02 per cent. lead, and 0.02 per cent. iron. All specimens were reduced 35.1 per cent. before annealing.

For the direct comparison of the Brinell hardness with the diameter of the average grain in millimeters, a third plot (Fig. 3) has been added for the 0.130-in. (3.3-mm.) gage brass. This plot emphasizes two points brought out in the foregoing paragraph: (1) At low temperatures the grain size is influenced by the grain size of the previous anneal (0.060 mm. ± in this case); and (2) from this grain size (0.060 mm.) upward, the Brinell hardness plotted against grain size gives a single curve no matter what the previous treatment of the metal has been. Consequently it may be repeated that in well-annealed brass of any given[6] alloy the Brinell hardness indicates grain size.

On account of the thickness of this particular brass as commercially used, the specimens were taken from a single bar as rolled in mill practice with a 35.1 per cent. reduction. In Fig. 2, the Brinell hardness and the grain size are plotted against annealing temperature so that they may be directly compared. The curves follow closely those of the 68 copper, 32 zinc alloy for the same percentage reduction and previous heat treatment.

Conclusion

1. The grain sizes of the annealed alloys 68 copper, 32 zinc and 69 copper, 31 zinc agree closely when the previous heat treatment and reduction by rolling are made to correspond. The difference in thickness —0.374-in. (9.4-mm.) gage and 0.130-in. (3.3-mm.) gage—does not appreciably affect the grain size or the Brinell hardness.

[6] The grain size and the Brinell hardness change progressively with the percentage of copper in brasses. The relation between the two, however, remains a constant for each brass mixture in the alpha phase.

2. The grain sizes of brasses annealed at low temperatures are greatly affected by the grain size and the reduction by rolling, previous to such annealing.

3. The grain size and Brinell data for the several conditions described, when plotted against temperature, give curves that approach the curve of metal annealed after hard rolling as a limit. It is desirable to select for standard of grain size (as determined by the temperature of annealing) those specimens that have been previously reduced by rolling at least 50 per cent.

4. In the case of cartridge brass of the composition 68 copper, 32 zinc, Brinell hardness indicates grain size. At low annealing temperatures the grain size is influenced by the grain size of the previous anneal. The finer the grain size of the previous anneal, the more closely will the curve, Brinell Hardness—Grain Size, approach the standard curve.

5. Since grain size is influenced by the grain size in the previous anneal and also by the amount of reduction by rolling previous to annealing, the hardness of cartridge brass may be determined with greater accuracy by the Brinell-hardness measurement than by attempting to judge it from the grain size.

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Does Forging Increase Specific Density of Steel?

BY H. E. DOERR,* ST. LOUIS, MO.

(New York Meeting, February, 1919).

THE writer has been unable to find much information relative to tests made to determine the effect of forging on the specific density of steel. The opinion, however, among men engaged in the business, seems to be that forging greatly compresses or consolidates the steel. While such is doubtless the case with spongy or porous steel, the following experiments indicate that there can be little or no change in the density with steel initially free from cavities.

Ten ingots of basic open-hearth steel cast as shown in Fig. 1 were used in the experiments. All the specimens were 0.53 carbon with all other elements the same, the analysis being determined from drillings taken midway between the center and outside of the upper end, as shown in Fig. 2. The specimens were selected from over one thousand ingots so that the tests could be comparative for the work done in forging only, but no two of the ingots were cast in the same heat. Each ingot remained in the mold approximately 30 min., when it was removed and air-cooled. About 12 hr. later, when the temperature had been reduced to approximately that of the surrounding atmosphere, the head was discarded and the ingot heated in an oil furnace to approximately 2250° F. (1235° C). Approximately 1 min. was required to forge under the steam hammer to 1¼ in. (31.75 mm.), rough diameter, as shown by the dotted lines in Fig. 2. All ingots were allowed to air-cool after forging. Cylinders ½ in. (17.7 mm.) in diameter and ½ in. high were then turned from the forged and unforged parts of the ingots and numbered. The ten pairs of specimens were submitted to Louis E. Endsley, Professor of Railway Mechanical Engineering, University of Pittsburgh; A. N. Talbot, Professor of Applied Mechanics, University of Illinois; L. Z. Slater, chief chemist, Scullin Steel Co., St. Louis, Mo. No information was furnished as to which specimens were forged or unforged and each laboratory used the same specimens, submitting the average of three independent determinations, a tabulation of which is shown in the accompanying table in which the laboratories are designated by

* Chief Mechanical Engineer, Scullin Steel Co.

the letters A, B, and C. While there is considerable difference in the individual determinations for a number of the specimens, the averages for both the forged and unforged specimens are very close. The determinations of each laboratory indicate that the forged is the denser of each pair with the single exception of "B's" determinations for No. 10. Assuming that all cavities, however small, were completely closed, the

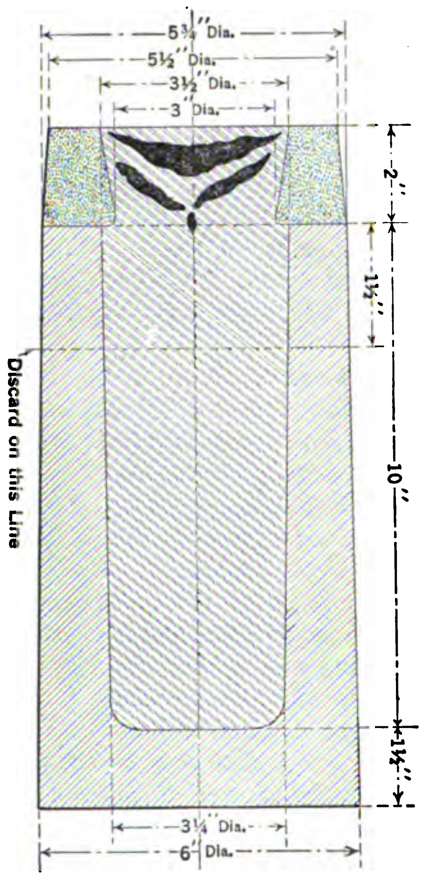


FIG. 1.—BASIC OPEN-HEARTH STEEL INGOT.

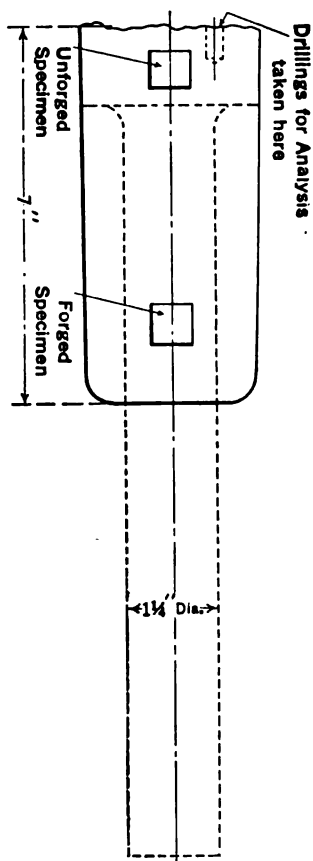


FIG. 2.—FORGED INGOT SHOWING POSITION OF SAMPLES.

average results indicate that only 0.64 per cent. of the sectional area of the original ingot consisted of cavities.

The ratio of volume to superficial area is so great with an ingot of the size used that it is doubtful whether the ingot can properly solidify without the formation of microscopic cavities. Undoubtedly, with large ingots where the ratio of volume to superficial area is smaller than with the ingots used, the percentage of increase in specific density of

the forged specimens would be reduced to a negligible value, if not wholly eliminated.

Effect of Forging on Specific Density of Steel

Specimen	Density Determined by Laboratory				Specimen	Density Determined by Laboratory			
	A	B	C	Average		A	B	C	Average
No. 1 forged......	7.807	7.86	7.826	7.831	No. 7 forged........	7.808	7.84	7.840	7.829
No. 1 unforged....	7.732	7.81	7.815	7.786	No. 7 unforged......	7.694	7.77	7.791	7.752
No. 2 forged......	7.825	7.85	7.824	7.833	No. 8 forged........	7.828	7.85	7.863	7.847
No. 2 unforged....	7.756	7.79	7.792	7.779	No. 8 unforged......	7.759	7.79	7.809	7.786
No. 3 forged......	7.810	7.85	7.818	7.826	No. 9 forged........	7.818	7.84	7.854	7.837
No. 3 unforged....	7.779	7.79	7.781	7.783	No. 9 unforged......	7.755	7.78	7.798	7.778
No. 4 forged......	7.837	7.84	7.875	7.851	No. 10 forged.......	7.820	7.85	7.873	7.848
No. 4 unforged....	7.774	7.80	7.790	7.788	No. 10 unforged.....	7.807	7.86	7.835	7.834
No. 5 forged......	7.828	7.86	7.829	7.839	Average of forged...	7.821	7.849	7.845	7.838
No. 5 unforged....	7.802	7.83	7.800	7.811	Average of unforged	7.762	7.798	7.803	7.788
No. 6 forged......	7.830	7.85	7.846	7.842	Increased density of forged, per cent....	0.76	0.65	0.54	0.64
No. 6 unforged....	7.761	7.76	7.814	7.778					

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Employment of Mine Labor

BY HERBERT M. WILSON,* PITTSBURGH, PA.

(New York Meeting, February, 1919)

This topic was discussed at the meeting in St. Louis in September, 1917, and at the meeting in New York in February last, but in the interval the war has accentuated in measurable degree the necessity for considering human relationship, not only as between nations, or in the treatment of our returning soldiers, but with respect to the relations between labor and capital in industry. It is my firm conviction that no other subject will have so large a place in industrial and political life during the next decade as this.

Heretofore, the employer has been so engrossed with the financial, mechanical, and technical aspects of his business that he has been willing to muddle through his relations with labor as best he might and, on the other hand, the laborer has been so engrossed in his endeavors to secure a livelihood under whatever living and working conditions might be offered him that he has given little thought to his relations to his employer, until some misunderstanding has ended in disagreement and strike. No thinking man doubts that were the machinery available for friendly, personal, face-to-face consideration of the problems confronting employer and employee, there would be fewer disagreements, fewer strikes, and a better and more settled industrial situation.

The necessity for some such medium for exchange of views has resulted in the organization of labor and, in some measure, of capital. Each party, engrossed only in defending its own viewpoint, has generally tried to gain its point by might rather than by right. Gradually, however, the representatives of both elements are beginning to appreciate that when the machinery for bringing them together in friendly communion is available their differences frequently settle themselves. There remain yet vast numbers of employers and of employees who are not organized and to whom the opportunity of friendly discussion of differences is not available; for these the machinery should be provided.

The subject, Employment of Labor, in so far as it applies to mine labor, may be considered under two headings: method of employment of labor and method of retention of labor. The method of treating each of these divisions of the subject will depend on the size of the mining operation. The method of employment for a large operation may be by

* Director of the Department of Inspection and Safety of the Associated Companies.

the maintenance of a separate employment department; for small mines, there may be no employment department or organized method of employment. The method of retention of labor will be affected by the size of the operation, the conditions of employment, as to its possible future permanency, the opportunity for promotion, and the general working and living conditions.

Employment by a large mining operation through a separate employment department should be governed by definite rules and methods. The hiring of labor should be governed by classification, a personal method of interview, and by consideration of the appropriate working place, and other conditions that will affect the prospective employee. The emoloyment and the retention of labor are affected not only by question of wages and chance of promotion, but by the conditions surrounding the work and the working place, and those connected with living opportunities. No aspect of the method of retention of the right kind of employee is more important than that which concerns the living and recreational opportunities offered near the place of employment. These have been generally treated under the titles of Safety Work and Welfare Work; the first deals with the place and conditions of the employment and the latter with the place and conditions of living. A better knowledge of the effect of these considerations on labor and employment has convinced, without exception, every one of those employers and employees who have had personal experience in such matters that an improved condition of safety adds to the efficiency of a mine operation and to the comfort and well-being of the miner; and that good living conditions, including housing and educational and recreational facilities, add in equal measure to the efficiency of the mine operation and to the comfort and well-being of the miner. Both of these so-called activities tend to reduce the cost of production, to increase the earning capacity of the employees, and to make for the more permanent retention of labor, and consequently the preservation of a higher grade of labor.

I will not elaborate now on the effect of safe practices in mining on labor employment,[1] nor on the effect of welfare work on labor employment,[2] as my views on these subjects have been given in previous meetings. Other subjects connected with the main topic of labor emoloyment, which I hope will be discussed by those better informed respecting their details, are the methods of separation, their effect on the reduction of labor turnover, and the necessity and wisdom of medical and health examinations both at the time of and during employment, and the relation of this latter inquiry to workmen's compensation costs, which latter subject I have presented in detail before your Section of the International Engineering Congress in San Francisco in 1915.

The question of separation is often one of the most difficult and most

[1] *Trans.* (1917) **57**, 557. [2] *Trans.* (1918) **59**, 652.

full of opportunity for misunderstanding. When either the business conditions or the personality of the employee may require his dismissal, it is necessary to decide how this shall be done in such manner as to make clear not only to the employee but to his associates that his separation is necessary. A common method is by a brusque notice of discharge; a better way would be by giving notice of one or more weeks prior to compulsory dismissal or by a personal interview with an opportunity for voluntary withdrawal within a fixed time.

A great deal of important and constructive work has been done toward the solution of the employment problem by a hundred of the larger mining corporations scattered from the Atlantic to the Pacific, notable among which are the mining subsidiaries of the United States Steel Corporation, the Republic Iron & Steel Co., Névada Consolidated Copper Co., Utah Copper Co., Cleveland Cliffs Iron Mining Co., New Jersey Zinc Co., and the Ellsworth Collieries Co. In like manner, among the smaller independent mining operations, there are many that are successfully handling this problem through the personal interest of the owner in the well-being of his employees. In this latter case the problem takes on the older paternal aspect of the subject, wherein the owner lives at his mining operation among his employees and takes a personal interest in them and in their family affairs, thereby securing to them better living and working conditions, and engendering a better spirit of friendly coöperation.

The most pretentious, and I think the most successful, recent effort to solve this problem is that begun three years ago under the personal direction of John D. Rockefeller, Jr., after the labor troubles of the Colorado Fuel & Iron Co. This effort is known as the Colorado Industrial Plan, and its success as a means of bringing about better relations between employer and employees and in securing more permanent and better labor employment conditions, appears to be amply testified to by the results of the past three years of successful operation. It is a striking example of the value of personal friendly conference, through the agency of a permanent establishment for the settlement of employees' troubles. In substance, it consists of a representative committee, selected by the miners and the owners, that meets at regular intervals to hear and inquire into the complaints of employees and the differences between employer and employee at each plant, respecting method of employment, retention, and separation. In the field of retention, this plan has adopted a most liberal attitude toward safe working conditions and satisfactory living conditions. It operates through committees on coöperation and consideration; on safety and accidents; on sanitation, health, and housing; and on recreation and education. These committees have accomplished much for the betterment of the working and living conditions of the miners and their families.

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Use of Cripples in Industry

BY JAMES P. MUNROE,* S. B. LITT. D., WASHINGTON, D. C.

(New York Meeting, February, 1919)

APPALLING as has been the loss of life in the last 51 months, there is one slight compensation: no longer will there be in the world a cripple, in the old meaning of the term. Men handicapped by wounds or disease, there will be, unfortunately, and in numbers beyond what the world has known since the wars of Napoleon; but neither they nor the industries from which they were called off to war will be "crippled" in the sense in which both would have been had mankind not learned the lesson of conservation and come to understand that the most important field for such conservation is not in the forests and the mines but among men and women.

From the beginning of the Great War, France, Great Britain, Belgium, and most of the other Allies have studied the problem of restoring the soldiers and sailors injured through war to physical and economic efficiency; and from their experiences, especially from that of Canada, the United States has learned much. Consequently, our task of preparing for the return of our disabled men has been easier and, in some ways, more comprehensive than theirs. Complex as are the details of the machinery which the United States has set in motion to take care of the men injured by wounds or disease, the plan itself is simple. Taught by European experience, the Surgeon-General of the Army and the Bureau of Medicine and Surgery of the Navy have provided, on both sides of the Atlantic, every known surgical and medical facility for restoring the injured or diseased man to a physical condition as nearly normal as possible. While in the hospital in France or England, on the transport coming to America, and in the hospital here, the disabled man is incited in every way to believe in his future efficiency, to want to be a normal worker, to desire to retake his place in that society of workers from which he went, temporarily, to do the greater work of preserving civilization. Furthermore, since purposeful occupation is now regarded as an essential form of treatment with most men in the hospital, especially in the convalescing stage, many of these men will have been actually started on the road to earning before they are discharged from the army surgeon's care.

* Vice-chairman, Federal Board for Vocational Education.

As soon as it is decided that a patient is ready for discharge from the hospital—and, now that hostilities have ceased, from the Army and Navy itself—his case is certified to two bodies: the War Risk Insurance Bureau, which is to determine the amount, if any, of his compensation under the War Risk Act, and the Federal Board for Vocational Education, which stands ready to help him to get back into employment and, if he needs it, to secure a preliminary training that will enable him to make the most of himself, under the conditions of his handicap, in that employment.

The Federal Board has no authority over the man thus placed under its care; it is for him to decide whether or not he wishes to avail himself of the help that the Federal Government thus offers. But if he chooses to use the facilities tendered by the Board, there is almost no limit, within reason, to what that organization may undertake for him. Its simplest task is, of course, to assist him in getting back into his old employment; but if he has ambition to get something better or if it is apparent that, by training, he can be more efficient in what he did before, the Board has authority to give him, at Government expense, as much education as, in its opinion, it is worth while for him to have. Every endeavor will be made to train the disabled man so that not only may his handicap be overcome, but that he may be carried, through an education perhaps denied to him before going to war, to a plane of efficiency which, without this opportunity, he could not have reached. Experience in other countries has shown that, in many instances, the disabled man is, after training and despite his handicap, a much more effective man than he was before the war.

While the disabled soldier or sailor is under no compulsion to take training, there are certain incentives, besides that of ambition, which the Government puts before him. If he desires to be trained and the Federal Board believes that he will profit by it, he is so certified to the War Risk Insurance Bureau, which at once classes him as entitled, during training, to the compensation provided for cases of temporary total disability, and, during the period of training, makes specified allotments to his dependents, should he have them. If he does not pursue the course of training with due diligence, these extra compensations, on representation of the Pederal Board, may be withdrawn.

Training will be carried on in public and private schools and colleges and in industrial plants under contracts made between them and the Federal Board. The period of training will be determined to meet the needs of each case, but in every instance the disabled man is to be regarded as a special problem and the instructional work given him will be fitted to his needs. It will be attempted, as far as possible, to obtain for him a position in advance of his being ready for it, so that his training may be focused upon a specific goal. Should it prove, after employment, that his choice was unwise, the Board has authority to give him further

training along that, or some new line. Moreover, after placement, whether with or without training, the Board will keep closely in touch with the man until it feels certain that he is firmly established in his industrial, commercial, or professional life.

To carry out the duty placed on it by Congress, the Federal Board has established, or is establishing, headquarters, in Washington and thirteen of the other leading cities of the country. As far as possible, the disabled man will be placed and trained in his own State and locality. Every effort will be made to put him into occupations that are growing, and so to train him that, when hard times come and the fervor of patriotism has passed, he will be retained, not because he is a former soldier or sailor but because he is a workman necessary to the work. Care will be taken, moreover, that he is not exploited and that he is not used as an instrument to disturb the labor situation. The complicated problems that might arise, in many States, in connection with employer's liability laws will not come up, since the number of disabled men is happily much less than it seemed probable that the United States would have.

The comparative smallness of the problem in the case of men injured in the pursuit of war serves but to emphasize the greatness of the number of men and women injured every year in the pursuit of the activities of peace. By the hundreds of thousands they meet with accident and injury in every degree and form. Heretofore, most of these injured persons, so far as their economic usefulness is concerned, have been thrown on the scrap-heap of society, with anguish to themselves and their relatives, with incalculable loss to the community. The war has taught us that this waste is needless and wrong; and if a bill now before the Congress becomes law, the Federal Board will be charged with providing, in coöperation with the several States, facilities for training and retraining these victims of industry along the same general lines as those followed with the victims of war. The task will be far greater than in the case of the disabled soldiers and sailors; it will not be, as with them, a comparatively temporary responsibility. It will go on forever, as long as there are machines, carelessness, and the inevitable lapses in human minds and senses, and the problem will have many complications that do not arise with those disabled in war. But the effects of rehabilitation in the field of industry will be as much broader in their final results as the scope of the permanent and normal arts of peace is greater than that of the temporary and abnormal art of war.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Need for Vocational Schools in Mining Communities

BY J. C. WRIGHT,* M. S., WASHINGTON, D. C.

(New York Meeting, February, 1919)

A PRACTICAL program of education for workers of the mining industries is being formulated by the Federal Board for Vocational Education in coöperation with the States in which this industry is a dominant one. The Federal Government last year passed a law, known as the Federal Vocational Education Act, that provides for the promotion of vocational education and for coöperation with the States in the promotion of such education in agriculture and trades and industries and in the preparation of teachers of vocational subjects.

More than 1,000,000 men in the continental United States are employed in mines and quarries. The following table, from the 1910 Census Report, shows the relative importance of mining and manufacturing pursuits:

	Manufactures	Mines and Quarries
Employees	7,405,313	1,109,410
Capital	$18,428,269,706	$3,380,525,841
Value of product	$20,672,051,870	$1,238,410,322

Of the more than 1,000,000 men employed in mining, almost three-fourths are engaged in the production of bituminous and anthracite coal; one-fifth, in the production of copper, iron, lead, zinc, and other metals; and the remainder in getting out structural and miscellaneous materials from quarries. The meeting of the needs of the coal-mining industry, therefore, is the problem of greatest importance in the point of numbers to be served. Moreover, the dangers in coal mining are greater than in metal mining.

Practically all States have set up educational and technical standards for the position of foreman, boss, superintendent, etc., and every applicant for these positions must have a certificate of competency. The qualifications, too, are becoming increasingly difficult in the field of technical information. In some States, every miner must have a certificate, which is issued by the mine examining board only after an oral examination.

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*Special Agent, Federal Board for Vocational Education.

Did these State laws not call for definite and comprehensive plans for the vocational education of men in the mining regions, the conditions under which coal and the metals are today brought out of the ground and made ready for the market would of themselves demand systematic practical training for those engaged in such large and increasing numbers in this important industry. Furthermore, since mines and smelteries are often distant from other industries and civic organizations, the responsibility of employers for the welfare of their employees is greater than in most other industries; by the nature of the enterprise, they must assume many of the burdens of public education and social betterment.

Previous to the present war, an increasing number of non-English-speaking men were migrating to mining communities. These were often experienced miners from Europe but were unable to read, write, or speak the English language. Preliminary and fundamental to vocational training, therefore, in many mining communities, is an effective course of instruction in the speaking and reading of English. In most mining districts, this need is understood and is beginning to be met by the public schools or by classes established by the employers. In far fewer instances, however, is it realized that the good of the community, as well as the welfare of the industry, calls also for evening classes, part-time classes, and, in some cases, day schools designed to give all employees sufficient technical knowledge to insure their own safety and that of their fellow-employees, and to provide, for the more ambitious boys and men, opportunities to fit themselves for State examinations, or to advance themselves in other ways.

The usual State school of mines is organized, very properly, as an engineering institution to train leaders in the industry. The course of study requires for entrance the completion of a four-year high-school course. Few of those employed in or about the mines, however, have even entered high school. Statistics for the State of Illinois show that, for every 1000 men, 251 had completed the fifth grade, 680 left school between the sixth and eighth grades, and 69 had completed more than the eighth grade.

A few State schools have been organized as miners' institutes and have offered courses of less than college grade. For example, the Illinois Miners and Mechanics Institute, as a means of offering to ambitious men an opportunity to prepare themselves for passing State examinations for mine inspector, mine manager, mine examiner, and operating engineer, offers: A two-year course of systematic instruction at mining centers; unit courses in mining towns; short course at the university; coöperation with existing organizations, such as the State Mining Board and inspectors, the Mine Rescue Station Commission, officials and locals of the United Mine Workers, the United States Bureau of Mines, high schools and grade schools, libraries in mining towns, first-aid or other

local organizations, and the Y. M. C. A.; also, as special activities, organization of local institutes, question and answer department, traveling libraries, laboratory equipment, etc., work for non-English-speaking miners, correspondence courses.

Owing to the failure of the necessary appropriation, this excellent work is suspended; and while other States are doing excellent work in this field, their efforts are sporadic, uncertain, and not coördinate. It would seem, then, that this field invites the coöperation of the Federal Government with the mining States and their local communities to promote methods of vocational education that will make better workmen, a more certain source of supply for positions of responsibility, and greater stability in the personnel of the working forces in the mines. Such coöperation is now possible under the terms of the Vocational Education Act.

The Federal Board is already coöperating with certain States in making surveys of typical industries. During the past year the agent for trade and industrial education in the West Central States held a number of conferences in mining communities with mine superintendents, foremen, and employees in an attempt to discover the kinds of schools and the type of instruction that the Federal Board might approve for vocational schools.

Under the terms of the Federal Act, three kinds of vocational schools may be organized:

The All-day School is intended to give to those who have not yet entered employment instruction that will enable them to receive advanced standing when they enter an industrial occupation. Pupils must be over 14 yr. of age and the school day must cover not less than 6 hr., three of which must be in work on a useful and productive basis. The all-day school organized in cities of over 25,000 presupposes that the pupil has selected a single trade for which he seeks entrance preparation. In cities under 25,000, and it is only with these smaller communities that mining is concerned, the length of the term may be shortened and the course of study varied so that several kinds of shop work may be included.

The Part-time School is organized for not less than 144 hr. per year and for pupils over 14 yr. of age. Instruction may be such as to increase the general civic or vocational intelligence of the pupils. Part-time schools for those who have entered employment may give trade preparatory, trade extension, or general continuation-school instruction.

The Evening School receives only pupils over 16 yr. of age and offers courses that supplement the daily employment of the individual.

These schools may be organized to meet the needs of those employed in and about mines in underground occupations as trappers, muckers, timbermen, roadmen, diggers, etc. The occupations above ground do

not differ greatly from corresponding occupations in other forms of industry.

A thorough study of the mining industry is needed to analyze the occupations, specify the operations that the individual must perform, list the technical information the individual must possess as an efficient workman, and prepare a course of study. As a result of the preliminary investigations already made, schools are being organized in the States of Oklahoma, Colorado and New Mexico. Reports from States in other regions indicate that similar schools are under way in Idaho, Nevada, West Virginia, Pennsylvania, etc. During the coming year, it is hoped greatly to extend the work.

The problem before the Federal and State Boards is one that requires the coöperation of the local community, employer and employee, and various mine organizations such as the American Institute of Mining Engineers, the American Federation of Labor, etc. This preliminary statement is made to stimulate discussion among those immediately concerned and to secure their suggestions and their active interest.

Oxygen and Sulphur in the Melting of Copper Cathodes—The Relation of Sulphur to the Overpoling of Copper

Discussion of the papers of STANISLAUS SKOWRONSKI, presented at the Milwaukee meeting, October, 1918, and printed in *Bulletin* No. 135, March, 1918, pp. 645 and 651.

GWILLIAM H. CLAMER* (Philadelphia, Pa.).—Sulphur is not so detrimental in its effect if oxygen is also present, so that in sulphur-carrying bronzes and brasses, it is advantageous to maintain a certain percentage of oxygen. As a matter of fact, it would be possible sometimes to correct difficulties by actually adding oxygen. If the cathodes were charged directly into an electric furnace in a neutral or reducing atmosphere, a very high grade of copper would result by a simple melting operation. This would very largely eliminate the loss occasioned by melting in a reverberatory furnace. In such a furnace a large amount of slag is produced during the oxidizing stage of refining. Notwithstanding the fact that melting in an electric furnace might be somewhat more expensive than melting in a fuel furnace, the ultimate result would be a saving and the production of a very high grade of copper.

Notes on Babbitt and Babbitted Bearings

Discussion of the paper of JESSE L. JONES, presented at the Milwaukee meeting, October, 1918, and printed in *Bulletin* No. 140, August, 1918, p. 1395.

GWILLIAM H. CLAMER (Philadelphia, Pa.).—About 16,000 tons of tin is used annually in the production of white metals. The real reason for using the so-called genuine babbitt, which is a high-tin base babbitt, perhaps in the majority of cases, is that tin has always been a high-priced metal and people naturally believe that what they pay a high price for must be good. Mr. Jones has shown that the common metal, lead, is a superior base for most purposes for which babbitt metal is used. The addition of lead is often looked upon as adulterant to genuine babbitt, and specifications for this reason rigidly restrict the lead content.

A sub-committee of the Society for Testing Materials, at the meeting in June, presented tentative specifications on babbitt metal, in which were included twelve formulas, containing from zero to 20 per cent. of tin, and several containing from 65 and 92 per cent. Babbitts containing

* First Vice-president and Secretary, Ajax Metal Co.

from 21 to 64 per cent. of tin soften at slightly elevated temperatures, and so are not as good as the babbitt metals that are strictly of lead base and which carry but a small percentage of tin. However, these intermediate babbitts can be cast in very thin sections, owing to their low melting point. Experience has now proved that the very best kind of bearing is one having a bronze back and a very thin lining of babbitt, and the thinner the better. Babbitt metals with a fairly high melting point must be cast rather heavy and afterward machined out; there is a possibility that these intermediate babbitts might be cast thin enough to avoid the necessity for boring and then gotten down to a fine bearing surface by simply reaming or hobbing.

JESSE L. JONES.—It is not altogether a question of the desire to use a high-priced material, for its fluidity has a lot to do with the adaptability of a babbitt. Tin-base babbitts are quite fluid and you can cover a large area with a rather thin lining. The viscosity of a lead-base babbitt at the pouring temperature is such that it requires skill to pour a thin lining into a bearing that has very much of an area. But if a lead-base babbitt is highly refined, fluid, and properly poured by trained men, you can get a good solid lining, free from blowholes, and in every way equal to the tin-base babbitt lining. The necessary care and supervision are well repaid on account of the difference in price between the lead-base and the tin-base babbitt.

So far Dr. Frary's alloy of lead, hardened with barium and calcium, has not proved very practical. With bearings of considerable area, the alloy must be poured in sections of about ½ in. (12.7 mm.) in order to get it to run, and the oxidation loss is considerable. If the temperature is kept down to avoid the oxidation loss, there is lack of fluidity. Of course, by reducing the amount of barium and calcium, the fluidity is increased, but you do not get the hardness, and it is necessary to have the hardness also. The first samples submitted were of about 16.5 Brinnell hardness as cast, and hardened, in a few weeks, to about 19 or 20. We asked for material of higher Brinnell hardness but it proved too sluggish to run into thin linings.

Volatility of Constituents of Brass

Discussion of the paper of JOHN JOHNSTON, presented at the Milwaukee meeting, October, 1918, and printed in the *Journal of the American Institute of Metals*, Vol. XII, No. 1, March, 1918.

J. W. RICHARDS* (South Bethlehem, Pa.).—The brass industry would find it very profitable to subsidize researches on the purely scien-

* Professor of Metallurgy, Lehigh University.

tific determination of the thermophysical properties of the brasses. The data we need most in connection with the brasses are the vapor tension of the zinc from the brasses at different temperatures, the heat of combination of zinc with copper to form different kinds of brasses, and the latent heat of fusion of these brasses at the melting temperature.

It is thermodynamically possible to take the formula for the vapor tension of zinc and calculate from it the vapor tension of the zinc from the brasses, if we know the heat of combination. The work done in volatilizing zinc alone is well known, the thermodynamic work of separating it from the copper is known for only one alloy, the 52 per cent. zinc alloy. It should be known for all the brasses. Then we could calculate the vapor tension of zinc from all the brasses in the liquid state as exactly as we know the vapor tension of zinc. If we know the latent heat of fusion of the brasses at the melting point, since the vapor tension of zinc from the solid brass at the melting point is the same as that from liquid brass, we can use that data for transforming the equation so as to give us the equation for the vapor tension of zinc from the solid brass, with mathematical certainty; also, we could in this way get the vapor tension of the zinc from the solid brasses down as low as we want to evaluate the formula—even to the ordinary temperature, as a matter of scientific curiosity.

Pure Carbon-free Manganese and Manganese Copper

Discussion of the paper of ARTHUR F. BRAID, presented at the Milwaukee meeting, October, 1918, and printed in *Bulletin* No. 143, November, 1918, p. 1697.

W. H. BASSETT,* Waterbury, Conn.—Manganese should not be expected to remedy all the defects that are due to poor melting practice. It is undoubtedly valuable in helping to eliminate porosity in many of the alloys. In the copper-nickel alloys, its use is becoming almost universal, for, beside helping to make sound castings, it tends to hold the carbon in solution in the solidified alloy.

GWILLIAM H. CLAMER,† Philadelphia, Pa.—I have found that manganese copper is satisfactory for eliminating sulfur and that it works very well in the crucible and when you have reducing conditions; but in a large reverberatory charge, where the conditions are oxidizing, we were not able to eliminate the sulfur.

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* The American Brass Co.

† First Vice-president and Secretary, Ajax Metal Co.

Low-temperature Distillation of Illinois and Indiana Coals

Discussion of the paper of G. W. TRAER, presented at the Milwaukee meeting, October, 1918, and printed in *Bulletin* No. 141, September, 1918, pp. 1463 to 1470.

G. W. TRAER (author's reply to discussion*).—Prof. Parr's discussion develops two points, upon which it seems desirable to comment. First, as to putting through a large enough tonnage to secure economic operation. At each manipulation of each oven 1500 lb. (680 kg.) of coal will be charged and the resultant coke discharged from a like amount of coal. Sixteen slabs will be discharged at each manipulation, each approximately 5½ in. by 11 in. by 6 ft. (14 cm. by 28 cm. by 1.8 m.). The operating schedule of a commercial plant, based upon our observations and calculations, indicates a "through put" of at least 12 tons of coal per day for each oven. We have made these figures conservatively and feel confident of materially exceeding them in a fully developed operating system. Our oven plant, with containers, will not cost as much as high-temperature plants of the same capacity. They do not require container equipment; but this is much more than offset by the cost of the great basal heat regenerative flues. Our operating requirements are quite susceptible to the application of mechanical devices and we believe our labor cost will be well within the necessary limit.

Second, as to Fig. 1 in my paper, showing the specific gravity of the tar. It was not intended to show that the specific gravity of the tar rises with decreasing heat, since of course the contrary is the fact. One of the curves shows the relation between temperature and specific gravity and the other the relation between temperature and yield. Our consulting engineer prepared the chart according to his customary method for showing two dimensions.

An Interpretation of the So-called Paraffin Dirt of the Gulf Coast Oil Fields

Discussion of the paper of ALBERT D. BROKAW, presented at the Colorado meeting, September, 1918, and printed in *Bulletin* No. 136, 1918, pp. 947 to 950.

EUGENE WESLEY SHAW,† Washington, D. C. (written discussion‡).—Paraffin earth is of especial interest because of the apparent difficulty of determining its chemical nature. I have submitted specimens to three chemists at different times with suggestions as to special tests that might be made. The results are indicated in the following reports:

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* Received Nov. 25, 1918. † U. S. Geological Survey. ‡ Received Nov. 8, 1918.

"The material contains a small amount of a faintly yellowish, waxy substance apparently of paraffin order. It also contains much anhydrous silica. From the dried material only 0.8 per cent. of soluble silica could be extracted."[1]

"The amount of material was very small and the waxy material extracted from it, only a minute trace, was too small for a very satisfactory examination. It proves, however, to be soluble in boiling absolute alcohol, but to precipitate out on cooling. On treatment with sulphuric acid only part of it was destroyed, the remaining particles having the appearance of paraffin wax. You are justified, therefore, in the conclusion that this is paraffin wax and not the solid fatty acid. The material is entirely insoluble in caustic alkalis."[2]

The analysis[3] of the third set of samples is as follows:

	Sample No. 1	Sample No. 2
Water at 130°	55.46	56.71
Loss on ignition above 130°	13.38	12.73
SiO_2	21.33	21.20
Fe_2O_3	1.73	1.67
Al_2O_3, etc.	6.09	5.86
CaO	0.36	0.43
MgO	0.31	0.47
K_2O	0.77	
Na_2O	0.20	
Combined carbon	3.13	
SiO_2 soluble in 5 per cent. NaOH	0.92	Does not form suspension in water.
Organic matter soluble in gasolene	0.01	

Sample No. 1 was collected by H. E. Minor, who suggests a reaction involving hydrogen sulfide and yielding colloidal silica.

Sample No. 2 was collected by Alexander Deussen, who suspects that the substance is mainly colloidal silica but contains a hydrocarbon akin to ozokerite.

According to the reports of David T. Day, who made the examination for the Bureau of Mines, and that of Chase Palmer, paraffin earth really contains paraffin; on the other hand, Wells and Minor report none. None of them seems to have found much colloidal silica. Ries, according to Woodruff,[4] reports that the paraffin earth is a hydrous aluminum silicate. Udden, according to Wrather,[5] concludes that it is dopplerite

[1] Chase Palmer: U. S. Geol. Sur., July 10, 1916.

[2] Report of the Director of the Bureau of Mines to the Director of the U. S. Geological Survey, Sept. 23, 1916.

[3] Made by R. C. Wells, of the U. S. Geological Survey. Reported Mar. 21, 1917.

[4] E. G. Woodruff: Discussion. *Bull.* No. 139 (July, 1918), 1153.

[5] W. E. Wrather: Discussion. *Bull.* No. 139 (July, 1918), 1151.

or phytocollite which contains neither aluminum nor silica. Considerable quantities of the natural jelly are obtainable and the difficulty in its identification or even of determining its general chemical character is indeed remarkable. Our most convincing line of argument seems to be that any substance whose chemical constitution cannot be determined from good-sized specimens must be humus.

That the substance is real admits of no argument even if there is disagreement in the reports of chemists and apparent difficulty in its isolation. That it is characteristic of the low Coastal Plain salt-dome country, if not confined to it, seems also satisfactorily established. That it is not dopplerite (composed of carbon, hydrogen, and oxygen in the proportions of about 10 : 12 : 5) or any other recognized hydrocarbon compound, seems evident from the chemical tests. That specimens from different localities are similar is true so far as known. Whether or not it consists largely or in part of colloidal silica produced by the action of gas, as suggested by Alexander Deussen,[6] seems to be still a question, as does also the suggestion by H. E. Minor[7] that H_2S may be an essential factor. Minor[8] reports as follows concerning one specimen: "It is practically insoluble in benzine, chloroform, alcohol, or benzol; however, it is almost wholly soluble in nitric acid and yields a residue of carbon with sulphuric acid. Upon distillation a thick reddish-brown fluid of offensive odor is obtained. In a slide made from the purest of the "paraffin" (a colorless, transparent, jelly-like mass) magnified 500 times, small rod-like objects are seen resembling bacteria."

In a later letter he writes, concerning a sample from New Iberia: "I found the sample to be literally alive with very small worms resembling earth worms, but much smaller in size. These worms died immediately upon exposure to the air, showing that in all probability they are anaerobic in nature. Upon puncturing the skin, it is seen that they secrete a large amount of sticky gelatinous substance. I do not wish to advance the idea that these worms are responsible for the formation of paraffin earth, as this may be only a local occurrence, but nevertheless it is of interest."

Paraffin, as Brokaw remarks, is said to have been found in peat; but even if paraffin is, under certain conditions, formed at the surface, it is safe to say that much of that which has been observed at the surface has migrated from considerable depth. Hence the occurrence of any paraffin, except marsh gas, at the surface is not valueless in oil prospecting. On the other hand, neither true paraffin nor paraffin earth can be regarded as a strong indication of oil.

As Kennedy[9] says, paraffin earth occurs both in oil fields and elsewhere.

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[6] Letter to writer. [7] Oral communication. [8] Letter to writer.

[9] William Kennedy: Discussion. *Bull.* No. 139 (July, 1918), 1146.

At least it is found in many places where oil has not yet been discovered, as, for example, in parts of Terrebonne Parish, La. Wrather[10] notes that sulfurous gases and considerable exposure to the air (lack of prolonged submergence) seem to be requisite and Woodruff[11] says that the substance "is not found where the surface strata are sand or very sandy clay." It seems to me that it will be well worth the cost to publish both laboratory and field observations such as these by Brokaw, Wrather and others, for more advancement has resulted in understanding this mysterious substance since last April (the date of Brokaw's paper) than in all the preceding years that paraffin earth has been known. Further, it seems to me probable, from the data now available, that it will be found that the substance develops under certain peculiar conditions only and that it is of more definite or restricted chemical composition than humus or peat, or "peat substance."

The Constitution of the Tin Bronzes

Discussion of the paper of Samuel L. Hoyt, presented at the Milwaukee meeting, October, 1918, and printed in *Bulletin* No. 144, December, 1918, pp. 1721 to 1727.

C. H. Bierbaum,* Buffalo, N. Y.—I agree with Dr. Merica that the eutectoid has a distinct effect upon the alloy and also that, as yet, it is difficult to say at just what point this eutectoid occurs or the conditions under which it appears; that is, the percentages of copper, tin, zinc, lead, and the other elements together with the temperature of pouring and the rate of cooling that is necessary; all seem to have a contributing effect. Some authorities, Law for instance, gives it as 9 per cent. of tin, yet under certain conditions I have found it with a lower percentage of tin to copper contents than that. The hard delta and the soft alpha crystals are both necessary for a bearing alloy; the one supplements the other.

I am not inclined to think that phosphorus has any effect upon the eutectoid forming. The phosphide, PCu_3, forms in and around the delta but is and remains distinct and separated from it. Etching with ferric chloride and then with nitric acid shows this very distinctly; it darkens the eutectoid and the other parts and leaves the phosphide bright. The rate of cooling determines the size of the crystals and the eutectoid together with their distribution and orientation. It is possible to chill the alloy to such an extent where no eutectoid appears. I think it has been positively demonstrated that only an alpha and a beta appear when this copper-tin alloy has been poured between two polished ingots

[10] W. E. Wrather: Discussion. *Bull.* No. 139 (July, 1918), 1148–1152.
[11] E. G. Woodruff: *Idem,* 1153.
* Lumen Bearing Co.

of copper and taking the exact point, as far as it would flow, almost a knife-edge, this very point after etching showed only an alpha and a beta as far as it showed anything; we found no sign of a delta. If the very edge or point of this alloy, cooled in this manner, is etched with either ferric chloride or with ammonia the surfaces show an entirely different structure. In the one case the high copper is obtained and in the other the high tin formation; in the one case there is a distinct crystalline formation, and in the other an almost amorphous condition. It becomes simply a question which reagent has been used for the etching.

The subject of bearings is ordinarily taken up from one point of view, that is, in considering the alloy only. The alloy used for a bearing should always be considered in conjunction with the corresponding bearing member, its composition and its hardness. If the steel journal is hard enough to receive the eutectoid crystal of the bronze, the bearing will be improved by it. On the other hand, if the steel is not hard enough the bearing will not be improved by the presence of the eutectoid.

S. L. Hoyt (author's reply to discussion*).—The example cited, by Dr. Merica, of the importance, to the technical man, of the present investigation is extremely interesting and may lead others to pursue the work even further than the writer has been able to. As to the occurrence of the so-called δ constituent in the bronze mentioned, Dr. Brinton and the writer have shown that the addition of zinc increases the magnitude of the upper heat effect so that, undoubtedly, δ would be found in greater quantities in the ternary alloys than in the pure copper-tin alloys. Presumably its tendency to form the undesirable envelopes would likewise increase. A heat treatment to overcome the formation of δ as envelopes, which might well be tried in technical practice, would be to quench from above the upper critical point and reheat to some lower temperature to produce the desired physical properties.

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* Received Nov. 22, 1918.

The Action of Reducing Gases on Hot Solid Copper

Discussion of the paper of NORMAN B. PILLING, presented at the Milwaukee meeting, October, 1918, and printed in *Bulletin* No. 142, October, 1918, pp. 1567 to 1580.

W. H. BASSETT,* Waterbury, Conn. (written discussion †).—The effect of reducing gases on hot solid copper has been known for many years in the copper industry, and precautions taken to guard against it in the general practice in copper heating and annealing. In view of the statement that Bengough and Hill, in 1910, were the first to suggest the possibility of the formation of gas within the copper itself, it is interesting to note that in *Harper's Magazine* for April, 1904, an article, "Life and Diseases of Mėtals," by Professor Heyn, illustrated the effect of reducing gases on copper by a photograph, which is shown in Fig. 1. This he entitled "Copper burst asunder by disease."

After referring to the effect of hydrogen on steel, he makes the following remark:

"Similar symptoms of poisoning, caused by hydrogen or gases containing hydrogen (as gas for lighting purposes), are apparent in copper when exposed to red heat. Not every kind of copper is susceptible to this poisoning in equal degree. Copper perfectly free of cuprous oxide is entirely exempt from poisoning. Most of the various coppers of commerce, however, contain cuprous oxide, formed during the smelting process while exposed to atmospheric influences. In such coppers, containing cuprous oxide, hydrogen causes a terrible disease on the copper being heated red hot. The copper bursts asunder and is permeated by cracks. This disease is practically incurable and can be eradicated by resmelting only. The results work destructively according to the amount of cuprous oxide contained in the copper."

It must have been evident to Professor Heyn, as it was to us on reading this article, that the bursting asunder of the copper was due to the formation of steam. Practical copper heaters have known for many years that it was quite possible to produce blisters, or large gas holes, in the interior of copper plates or bars by heating to a high temperature in reducing gases. These facts, of course, do not detract from the value of the study of the action of hydrogen gas that has been made by Mr. Pilling, but simply illustrate that the practical effect of reducing gases on furnace-refined copper has long been a troublesome factor in the heating or annealing of that metal.

It would be very interesting to know what Mr. Pilling means by "commercial-conductivity" copper, since the usual terms under which copper is specified are electrolytic or lake copper; the lake being divided

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† Received Nov. 27, 1918.

into two grades known as low-resistance, or high-conductivity, and high-resistance, or low-conductivity copper. The electrolytic and low-resistance lake copper are both non-arsenical.

The lead figure given is somewhat surprising, because copper with 0.15 per cent. lead could be hot rolled only with great difficulty. This amount of lead would result in the serious cracking of edges in plates and cross cracking in rods. Ordinarily good electrolytic or lake copper does not carry more than 0.001 or 0.002 per cent. of lead.

We cannot quite agree with the author that oxygen normally occurs mechanically mixed with metallic copper in the form of Cu_2O. Furnace-refined copper, whether cast or wrought, is usually thought of as an alloy of copper with cuprous oxide, and the eutectic of copper with cuprous oxide is usually found between the crystals of pure copper, whether in the cast or the wrought form. It is true that there may be inclosures of eutectic within the grains of pure copper, particularly in the wrought material, but there is strong evidence for believing it occurs mainly between the grains. This is indicated in Figs. 2 and 3, which show the surface of wrought copper, in which the grains are strongly outlined, or parted, and where the spots resulting from reduction of suboxide in eutectic appear more frequently on the grain boundaries than elsewhere. This condition is also shown in Figs. 4 and 5, which show a cross-section of a rectangular bar of copper, where the grains are separated in the deoxidized part and the deoxidized part is partly separated from the mass of the material, probably because it occupies a larger volume than it originally did. The effects of rolling material of this kind where the grains have been separated by deoxidation are shown in Fig. 6.

The effect of various gases on refined copper is shown in a series of four micrographs of copper that has been heated to 800° C. The first, Fig. 7, shows the effect of hydrogen on refined copper; the second, Fig. 8, the want of effect of hydrogen on copper that has been deoxidized by boron-suboxide; the third, Fig. 9, the effect of carbon dioxide on refined strip copper; and the fourth, Fig. 10, the effect of nitrogen on similar material. The larger the amount of oxygen, the greater is the effect of reducing gases. For instance, two lots of strip copper that had been taken from bars coming from the same furnace charge, one containing 0.094 per cent. of oxygen and the other 0.015 per cent. of oxygen, were reduced in tensile strength by annealing for 1 hr. in an atmosphere of illuminating gas at 600° C. the amounts here shown.

Sample	Original Tensile Strength, Lb. per Sq. In.	Tensile Strength After Gassing, Lb. per Sq. In.	Original Elongation in 2 In., Per Cent.	Elongation After Gassing, Per Cent.
L-1..........	34,000	24,350	36.5	13.0
L-11.........	33,500	28,150	38.0	26.3

FIG. 1.

FIG. 2.

FIG. 3.

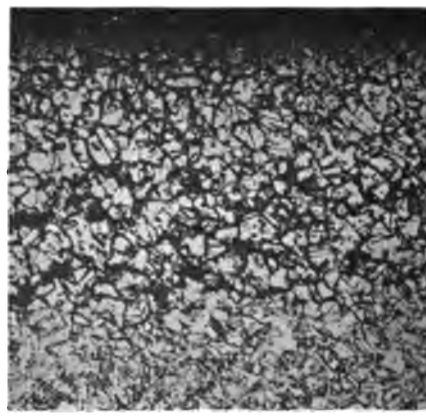

FIG. 4.

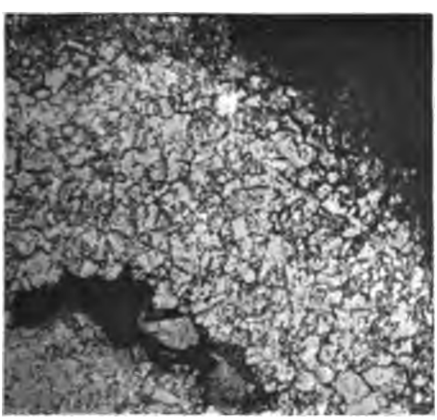

FIG. 5.

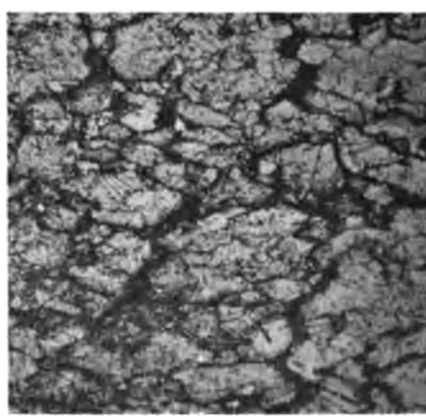

FIG. 6.

PLATE I.—FIGS. 2 TO 5 ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. × 75.

This indicates a reduction of 28.3 and 16 per cent., respectively, in tensile strength; and 64 and 44 per cent., respectively, in elongation.

The presence of arsenic apparently protects copper from the action of reducing gases to some extent, while the presence of nickel has the

FIG. 7.

FIG. 8.

FIG. 9.

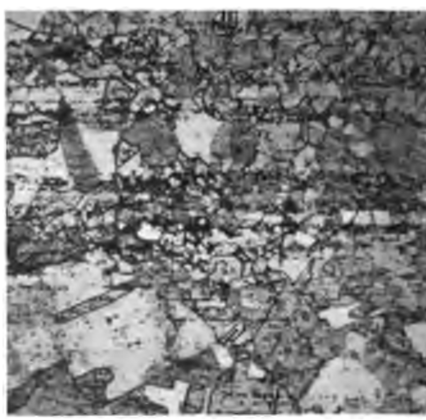

FIG. 10.

PLATE II.—ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE. × 75.

opposite effect. The rate of penetration by reducing gases does not seem to be greatly affected by the amount of oxygen alloy present, as may be noted from Fig. 11, which gives the depth of penetration of both hard and annealed copper rods 0.364 in. in diameter for 1 hr. heating at various temperatures in an atmosphere of illuminating gas.

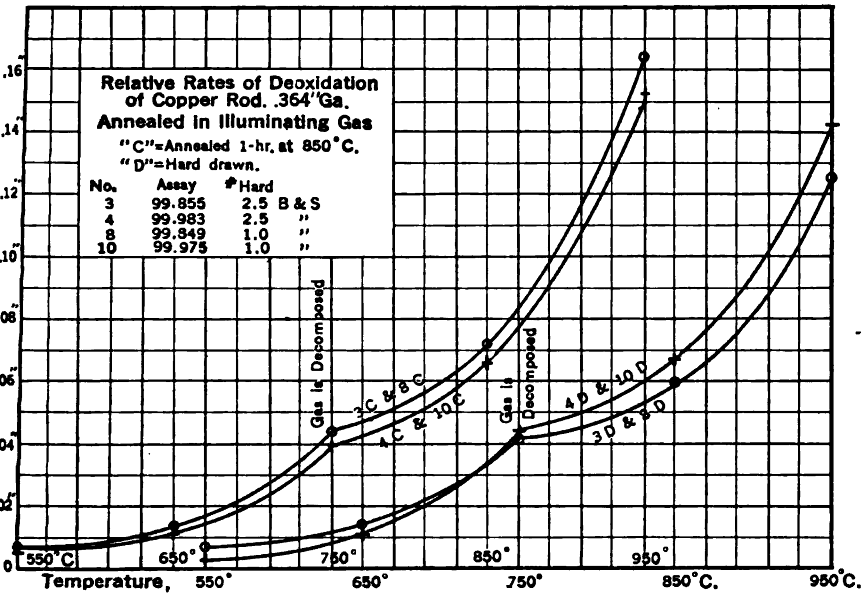

FIG. 11.

The Effect of Oxygen upon the Precipitation of Metals from Cyanide Solutions

Discussion of the paper of T. B. CROWE, presented at the Colorado meeting, September, 1918, and printed in *Bulletin* No. 140, August, 1918, p. 1279.

LOUIS D. MILLS, San Francisco, Cal. (written discussion*).—The principle involved in the Crowe vacuum precipitation process is so elementary and the apparatus required is so simple, that the whole subject affords scant material for a technical discussion. As one prominent Colorado metallurgist recently remarked when asked to contribute to this paper: "The Crowe process is the biggest step forward since the early days of the cyanide process, but there is nothing to write about; just put it in your mill and try it." The writer confesses to a similar feeling, but having been closely identified with the process since its inception in 1916, he is perhaps in a position to at least comment on the theory involved and to record some of the results that have been achieved in actual practise.

In practising the Crowe process, the solutions to be precipitated are first vacuumized in a suitable dispersion tower; that is, thin films of the liquid are subject to the action of a vacuum within a receiver. Sub-

* Received Nov. 12, 1918.

stantially all of the dissolved air is thus removed through the vacuum pump, and the treated solution is sent to precipitation without further opportunity for re-absorption of air. The time of contact required is short and the amount of power consumed is very small. A receiver 6 ft. (1.8 m.) in diameter by 12 ft. long handles upward of 3000 tons of solution in 24 hr. or 500 gal. (1892 l.) per min., with a consumption of under 1 hp. No supervision is required other than to insure the proper operation of the small vacuum pump and motor, the flow of solution being entirely automatic.

The actual precipitation of the metals may be accomplished by any of the well-known methods, as, for instance, in zinc shavings boxes or by the use of powdered precipitants, such as zinc, aluminum, or charcoal, as in the Merrill process. The writer agrees with Mr. Crowe, that the true precipitating or reducing agent is invariably nascent hydrogen. This hydrogen is probably evolved first by the dissolution of the precipitant in caustic alkali and the reaction continues as long as fresh precipitant is exposed to the solvent. A portion of the hydrogen evolved by this dissolution is lost, as far as the operation of precipitation is concerned, by combining with the oxygen of the dissolved air contained in all cyanide solutions.

The amount of dissolved oxygen in such solutions depends upon the pressure and agitation to which the solutions have been subjected. Contact with reducing minerals of the ore tends to rob the solution of its oxygen, but, to insure maximum dissolution of the precious metals, the oxygen content is kept as near as possible to the saturation point. The solubility of oxygen in cyanide solutions varies inversely with the temperature, being relatively much greater in cold solutions than in warm solutions. This explains the well-recognized advantages of warming cyanide solutions during cold weather.

The oxygen contents of normal treatment solutions varies from 4 to 8 mg. per liter, and 6 mg. may be taken as an average figure.[1] The usual equations show that 6 mg. of oxygen per liter are equivalent to[2]

0.012 lb. of oxygen per ton of solution.
0.049 lb. of zinc per ton of solution.
0.195 lb. of potassium cyanide per ton of solution.
0.150 lb. of sodium cyanide per ton of solution.

Thus it is evident that in precipitating a solution containing in excess of 0.20 lb. KCy or 0.15 lb. NaCy sufficient zinc must be wastefully dis-

[1] W. A. Caldecott: Chemistry of Banket Ore Treatment, in "A Text Book of Rand Metallurgical Practice," by Ralph Stokes and Others. **1**, 385. London, 1912, C. Griffin & Co., Ltd.

[2] H. A. White: The Estimation of Oxygen in Working Cyanide Solutions. *Jnl.* Chem., Met. and Min. Soc. S. A. (June, 1918) **18**, No. 12, 296.

solved to satisfy the dissolved oxygen present, the ultimate product being the double salt $Na_2 Zn Cy_4$, and the quantities entering into the reaction being 0.012 lb. of oxygen, 0.049 lb. of zinc and 0.150 lb. of sodium cyanide, respectively. The removal of this oxygen prior to precipitation should therefore reduce the consumptions of zinc and cyanide by the foregoing amounts, and it is of interest to note that this exact result has been found in the application of the Crowe process.

At the Belmont mill in Tonopah the chemical consumptions prior to the installation of the vacuum process were as follows: Zn, 0.772 oz. per fine ounce of silver recovered; NaCy, 2.850 lb. per ton ore milled. After installing the vacuum process, the figures became: Zn, 0.650 oz. per fine ounce silver recovered, which corresponds to a saving of 0.14 lb. per ton ore milled; at the same time the cyanide consumption was reduced to NaCy, 2.40 lb. per ton ore milled, or a saving of 0.45 lb. per ton ore milled.

Since at this plant the ratio of solution precipitated to ore milled is very close to 3:1, the actual reductions per ton of solution precipitated, namely 0.046 Zn and 0.15 NaCy, are practically identical with the theoretical figures.

Considered from an economic standpoint and remembering that zinc and sodium cyanide are at present worth approximately $0.15 per lb. and $0.30 per lb., respectively, the foregoing figures furnish a convincing illustration of the value of the Crowe process, the saving in chemicals alone being in excess of $0.15 per ton of ore milled.

The Condensation of Zinc from Its Vapor

Discussion of the paper of C. H. FULTON, presented at the Colorado meeting, September, 1918, and printed in *Bulletin* No. 140, August, 1918, p. 1375.

CHARLES H. FULTON (author's reply to discussion*).—Mr. E. E. Thum is kind enough to point out an apparent discrepancy between the conclusions drawn from experiments and the results of those experiments. It is stated on page 1383 that carbon dioxide in excess of 1 per cent. is not found in the gases above the carbon reduction temperature (of zinc oxide). This statement refers to such temperatures as occur in ordinary zinc distillation and is not meant to include temperatures above 1350° C., and it should have been so stated in the original paper. When the temperature of the distilling chamber reached 1400° and above, it was noted that the amount of carbon dioxide in the gases increased. This cannot be explained by the equilibrium of the reaction $2CO \rightleftarrows CO_2 + C$, and in seeking reasons for the discrepancy, the experiments of Meyer

* Received Nov. 29, 1918.

and Langer, cited in the original paper, were found. These experiments were carried out for the purpose of studying decomposition of gases at high temperature and the determination of molecular weights. The temperatures were attained in a platinum tube, proved tight by experiment. The paper states that at 1200° C. carbon monoxide remains unchanged, but that at 1690° C. there was a partial decomposition into carbon dioxide and carbon. Carbon dioxide at this high temperature showed traces only of decomposition. According to Nernst and von Wartenberg, the decomposition is into carbon monoxide and oxygen.[1]

These results offer an explanation for the increase of carbon dioxide in the distillation gases produced at high temperatures. The analysis of the gas, of course, is made after it has passed from the point of origin in the high temperature region, through the region of intermediate temperature, to the point of sampling. What happens in the interval between origin and sampling is not known, and the gas analysis reveals only the final result. It is perfectly possible that instead of $2CO \leftrightarrows CO_2 + C$ reversing itself at the high temperature and proceeding from left to right, the carbon monoxide is partly dissociated into carbon and oxygen and then that, as the gas passes to cooler regions, the oxygen unites with carbon monoxide with the consequent production of carbon dioxide. The fact remains that when the temperature of distillation is high at the end increased quantities of carbon dioxide appear.

The tightness of the quartz and porcelain tubes used was tested as follows: The middle portion of the tube was heated to a maximum normal distilling temperature of 1350° C. in the electric furnace, the atmosphere around the outside of the tubes being essentially one of carbon monoxide due to the nature of the electric furnace. Purified nitrogen gas was then passed through the tube; this was carefully analyzed before entrance and after passage through the tubes, and no change in gas composition was noted. Whether the tubes are tight at 1500° C., I am unable to say. The high temperatures of 1400 to 1500° C. were not the normal temperatures worked with and were reached only occasionally at the very end of the distillation and then prevailed for very short periods of time. The use of thermo-couples for the high temperatures, in reducing atmospheres, particularly when zinc vapor is present, presents serious difficulties. In the highest temperatures measured in the experimental work detailed in the paper, the hot junction end of the couple was in each case destroyed and the couple had to be shortened and recalibrated before it could be used again.

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[1] W. Nernst and H. von Wartenberg: Die Dissociation von Wasserdampf. *Zeit. für Phys. Chem.* (1906) **56**, 534.

INDUSTRIAL SECTION

This department is devoted to material concerning the products or operations of manufacturers, which, in the estimation of the Editor, is of news value to the mining and metallurgical field, but does not come within the scope of the main editorial section of the Bulletin.

Manufacturers are invited to submit to the Editor items descriptive of new equipment or processes, large or significant installations, and similar material of news character. If found available, items thus furnished will be published in this section without charge, subject to such editorial revision and condensation as may be necessary.

In cases where illustrations are required, cuts of the proper size should accompany the text matter.

TYPES OF SASH TO BE USED IN A MONITOR

The use of sash in monitor construction pre-supposes a building of the foundry or forge-shop type in which the ventilating problem is the removal of heat or gases, a "hot building" as it is sometimes called. To secure the maximum amount of ventilation in buildings of this type, usually, it is possible to follow certain fundamental principles with some fair degree of consistency. In the removal of gases from buildings by the natural or gravity method, the only forces at work are those working in the chimney; and they are governed by the same laws as those of the chimney. In applying these laws to such buildings as forge shops and foundries, the following points are of great importance:

1. The column of hot air should be made as high as possible by elevating the roof as far as practical.
2. The gases should leave at the greatest possible height and the roof should be designed to give the greatest freedom of exit.
3. The gases should enter at the lowest point of the building (near the floor) and the intake should be as free as possible.
4. The side walls of the building should be normally closed between the intake and the exit so as to prevent cross draft and interference with the floor gases.
5. The source of heat, such as furnaces and molding floors, should be placed, in so far as practical, directly beneath the open monitor so as to give the greatest power to rising gases.

Fenestra Monitor sash provide the maximum lighting, ventilation, and weather protection required by architects and engineers. They may be designed to run between columns or past columns the entire length of the building, thus giving a continuous weather-tight area of glass with ventilators controlled by mechanical operating devices in continuous lines of almost any length. When desired, the operator may be connected to an electric control and the sash opened by the pressing of a button on the moving of a switch. All sash are made from solid, rolled-steel bars. Particular attention has been given to the assembling of the sash and to the joining of the various units with a view to securing maximum strength and rigidity.

TRADE CATALOGS

(Under this heading will be listed such catalogs or other advertising literature as may be received during the preceding month. Contributors should address their material to Engineering Societies' Library, 29 West 39th St., New York.)

GEM STOPPER CO. Philadelphia, Pa.
Bulletin No. 8. Universal acid carboy stoppers, asbestos gaskets, and metal fasteners. 1918.

GENERAL FIRE EXTINGUISHER CO. Providence, R. I.
The Grinnell sypho-chemical sprinkler system. Descriptive booklet. 1917.

HIRES TURNER GLASS CO. Philadelphia, Pa.
Bulletin No. 2. Wire Glass and Why.

JEFFREY MFG. CO. Columbus, Ohio.
Bulletin No. 246. Jeffrey pit-car loader.

JONES & LAMSON MACHINE CO. Springfield, Vt.
The Fay automatic lathe; a machine for the automatic turning of work held on centers or on centered arbors. 1918.

LUITWIELER PUMPING ENGINE CO. Rochester, N. Y.
Illustrations and descriptions of non-pulsating power pumps.

SYPHO-CHEMICAL SPRINKLER CORPORATION. New York, N. Y.
The combination of a system and a service. 1916.
Service of protection. 1916.

The Scottish shale industry is now annually yielding 70,000 gal. of oil and 60,000 tons of ammonia.

It was recently stated in Parliament that up to July, 1918, Great Britain had paid £47,000,000 to iron and steel manufacturers in subsidies since the war began.

According to a report of the U. S. Geological Survey, domestic mines shipped 136,554 gross tons of ore containing more than 35 per cent. of manganese in the first 6 mo. of 1918.

Earl Curzon has declared that the Allied cause was "floated to victory on a wave of oil," because if it had not been for the great fleets of motor trucks the war could not have been won. In the last 18 mo. of the war, the Allied Petroleum Council dealt with 13,000,000 tons of oil. In December, 1916, the oil situation was critical; stocks were so depleted that the British fleet was obliged to restrict operations. But by transporting 1,000,000 tons of oil in the double bottoms of ordinary cargo vessels, the stocks of oil in Allied countries, when the armistice was signed, had been brought up to a point of absolute safety.

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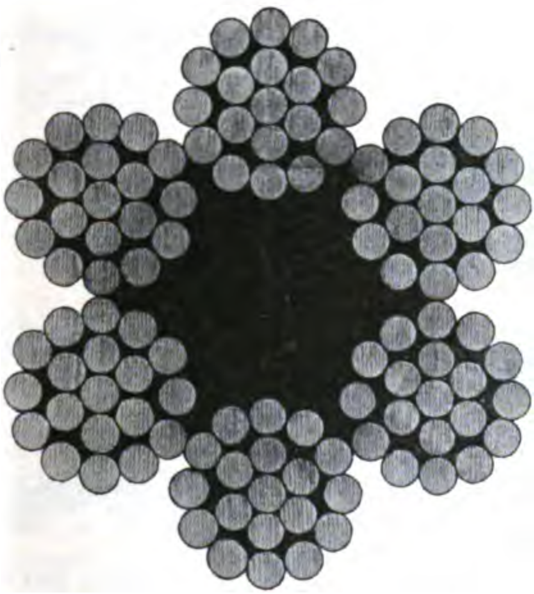

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THE MINING AND METALLURGICAL INDEX

November, 1918

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MINERAL RESOURCES

(Except Petroleum and Gas. See also Mining Geology and Mining Practice.)

ANTIMONY, graphite, nickel, potash, strontium, tin. E. S. Boalich and W. O. Castello, California State Min. Bur. *Preliminary Report No.* 5 (Mar., 1918) 6–44. 38 p.

AQUEOUS and igneous rocks. *Sci. & Art of Min.* (Nov. 2, 1918) **29** 107–8. 800 w.

ASBESTOS, chromite, graphite, magnesite, mica, and molybdenite in Quebec. *Min. & Sci. Pr.* (Nov. 9, 1918) **117**, 625–7. 2200 w. Notes from Annual Report for 1917 of T. C. Denis, Provincial Superintendent of Mines.

AUSTRALIAN tin industry is encouraged. *Iron Tr. Rev.* (Nov. 21, 1918) **63**, 1182. 300 w.

BELCHER Islands, Discovery and exploration of the. R. J. Flaherty, *Canad. Min. Jnl.* (Nov. 1, 1918) **39**, 369–72. 3500 w. From *Geol. Rev.*, June, 1918, Abs.

CARBONIFEROUS deposits in provinces of Pallasca, Huaylas and Yungay. J. M. Yanez Leon, Yacimientos carboníferos de las provincias de Pallasca, Huaylas y Yungay. *Bol.* Cuerpo Ingen. de Minas Peru (1918) No. 90, 8–85.

CHROME and manganese in Cuba. *Min. & Sci. Pr.* (Nov. 9, 1918) **117**, 628. 600 w. From U. S. Geol. Sur. *Bull.* 380, Sept., 1918, Abs.

CHROME scandal. *Min. & Sci. Pr.* (Nov. 2, 1918) **117**, 584. 700 w.

CHROMITE and manganese. Edit. *Min. & Sci. Pr.* (Nov. 23, 1918) **117**, 678–9. 900 w.

CHROMITE situation. *Min. Cong. Jnl.* (Nov., 1918) **4**, 416–7. 900 w.

COAL and iron resources of Chattanooga District. E. M. Jones, Paper presented before Am. Electrochem. Soc. *No.* 21 (May 1, 1918) 153–4. 600 w.

COPPER deposits of Caucasus. *Russia* (Oct., Nov., 1918) **3**, 11–13. 1200 w.

COPPER distribution in Mexico. *Min. & Sci. Pr.* (Nov. 16, 1918) **117**, 658. 300 w.

COPPER, Production of, is to be maintained. *Elect. Wld.* (Nov. 23, 1918) **72**, 1005. 200 w.

GERMANY losing grip on iron and steel sources *Canad. Foundryman* (Oct., 1918) **9**, 255–6 1200 w.

GOLD district of Venezuela. H. H. Miller, *Min. & Sci. Pr.* (Nov. 16, 1918) **117**, 651–3. 1800 w.

GOLD mining, Crisis in. *South Afr. Min. Jnl.* (Sept. 28, 1918) **28**, 45. 500 w.

GOLD problem. W. de L. Benedict, *Min. & Sci. Pr.* (Nov. 16, 1918) **117**, 650. 600 w. Letter.

GOLD problem, Solution of. *South Afr. Min. Jnl.* (Sept. 14, 1918) **28**, 3. 600 w.

GOLD producer, Help for. Edit. *Chem. & Met. Engng.* (Nov. 1, 1918) **19**, 650. 500 w.

GOLD production national question. Edit. *Min. Cong. Jnl.* (Nov., 1918) **4**, 412. 400 w.

GOLD production, Suggested stimulation of. *Queensland Govt. Min. Jnl.* (Sept. 16, 1918) **19**, 415. 700 w.

GOLD question. W. R. Ingalls, *Engng. & Min. Jnl.* (Nov. 23, 1918) **106**, 907–8. 1000 w. Letter.

GOLD question in America. *South Afr. Min. Jnl.* (Sept. 14, 1918) **28**, 7–8. 1800 w.

GOLD standard. W. Karri-Davies, *Min. & Sci. Pr.* (Nov. 9, 1918) **117**, 617–8. 1300 w. Letter.

GOLD will come back. Edit. *Min. Cong. Jnl.* (Nov., 1918) **4**, 409. 500 w.

IRON and coal in the Ukraine. *Iron & Coal Tr. Rev.* (Nov. 1, 1918) **97**, 490. 800 w.

IRON, Future of. *Iron & Coal Tr. Rev.* (Oct. 25, 1918) **97**, 463. 600 w.

IRON, Future of, trade. G. Carrington, *Iron & Steel Tr. Jnl.* (Oct. 26, 1918) 459–60. 2500 w. Address delivered by President of Staffordshire Iron & Steel Inst., Oct. 19, 1918.

IRON ore in 1917. *Steel & Metal Digest* (Nov., 1918) **8**, 639–40. 1200 w.

IRON ore resources of Brasil. E. C. Harder, *Lefax* (Oct., 1918) **8**, 65–6. 1000 w. From *Bull.* A. I. M. E., Sept., 1918.

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(See also Mineral Resources)

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ORE-DRESSING AND PREPARATION OF COAL

CHROMITE, Sampling and analysis. A. A. Hanks, *Min. & Sci. Pr.* (Nov. 16, 1918) **117**, 654–5. 1000 w.

COAL handling, Saving $3000 per year. *Elect. Ry. Jnl.* (Nov. 9, 1918) **52**, 844. 500 w.

COAL washing: A scientific study. T. J. Brakeley, *Trans.* Manchester Geol. & Min. Soc. (May, 1918) **35**, 244–85. 42 p.

CONCENTRATING ores. W. W. Webster, British Pat. 119050. *Ill. Off. Jnl.* (Nov. 13, 1918) 2598. 100 w.

CONCENTRATING ores. W. A. Scott, Brit. Pat. 118627. *Ill. Off. Jnl.* (Oct. 30, 1918) 2434. 100 w.

CONCENTRATION, Apparatus for ore. F. Groch, U. S. Pat. 1281351. *Off. Gaz.* (Oct. 15, 1918) **255**, 400. 300 w.

DRY-concentration plant at Arkansas. T. Shiras, *Engng. & Min. Jnl.* (Nov. 23, 1918) **106**, 909–10. 1200 w.

ELECTRO-magnetic ore separation. *South Afr. Engng.* (Sept., 1918) **29**, 131–2. 500 w.

ELECTROSTATIC precipitation. E. P. Mathewson, *Min. & Sci. Pr.* (Nov. 9, 1918) **117**, 632. From A. I. M. E. *Bull.*, Nov., 1918. Discussion of paper by O. H. Eschholz, A. I. M. E. *Bull.*, Aug., 1918.

FLOTATION and colloids. *Salt Lake Min. Rev.* (Nov. 15, 1918) **20**, 26–7. 700 w.

FLOTATION at Highland Valley mines, Notes on. F. Keffer, *Bull.* Canad. Min. Inst. (Nov., 1918) 932–6. 1500 w.

FLOTATION, Differential, of lead and zinc sulphides. A. Del Mar, *Min. & Sci. Pr.* (Nov. 23, 1918) **117**, 691–3. 1600 w.

FLOTATION, Kay mine an ideal, proposition. F. W. Bower, *Ariz. Min. Jnl.* (Nov., 1918) **2**, 23. 800 w.

FLOTATION, Mill practice at, plant of Utah Leasing Co. H. H. Adams, *Salt Lake Min. Rev.* (Nov. 15, 1918) **20**, 21–5. 3000 w.

FLOTATION, Theory of process. K. Sundberg. Flytprocessernas teori. *Jern-Kont Ann.* (1918) No. 3 and 4, 105–64. 59 p.

GOLD concentrator. A. Robinson Mackie, Canad. Pat. 185636. *Pat. Off. Rec.* (July, 1918) **46**, 2156. 400 w.

MAGNETIC separator. New Jersey Zinc Co., Canad. Pat. 185864. *Pat. Off. Rec.* (July, 1918) **46**, 2264–5. 2000 w.

OLIVER filter modifications. C. T. Rice, *Engng. & Min. Jnl.* (Nov. 23, 1918) **106**, 899. 500 w.

ORE-dressing, Hazards and safeguards in, plants. J. S. McKaig, *Engng. & Min. Jnl.* (Nov. 23, 1918) **106**, 897–9. 1500 w.

ORE-pulp, Automatic separation of solution from solids in. B. MacDonald, *Min. & Sci. Pr.* (Nov. 23, 1918) **117**, 695–6. 1100 w. From *Bull.* A. I. M. E., July, 1918, Abs.

ORE screen. J. Nichols, U. S. Pat. 1282108. *Off. Gaz.* (Oct. 22, 1918) **255**, 642. 400 w.

ORES, Concentrating. W. McDermott, Brit. Pat. 118074. *Ill. Off. Jnl.* (Oct. 9, 1918) 2219. 100 w.

RADIUM, New ore plant. *Salt Lake Min. Rev* (Nov. 15, 1918) **20**. 300 w.

SCREENING apparatus. W. D. Richardson, U. S. Pat. 1282127. *Off. Gaz.* (Oct. 22, 1918) **255**, 649. 400 w.

SEPARATING slate from coal, A new method. H. M. Chance, *Sci. Am. Sup.* (Nov. 30 ,1918) **86**, 348–50. 5000 w.

SINTERING ores, Method of. E. J. Heilman, U. S. Pat. 1280221. *Off. Gaz.* (Oct. 1, 1918) **255**, 30. 500 w.

SLIME concentration. *Min. Mag.* (Oct., 1918) **19**, 176–7. 600 w.

TAILING excavator at plant of New Cornelia Copper Co., Ajo, Ariz. *Bull.* Am. Inst. Min. Engrs. (Nov., 1918) 1670–2. 1000 w. Discussion of paper by F. Moeller in A. I. M. E. *Bull.* 140, Aug., 1918.

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(See also Mineral Resources, Mining Geology and Mining Practice, Ore-dressing and Preparation of Coal)

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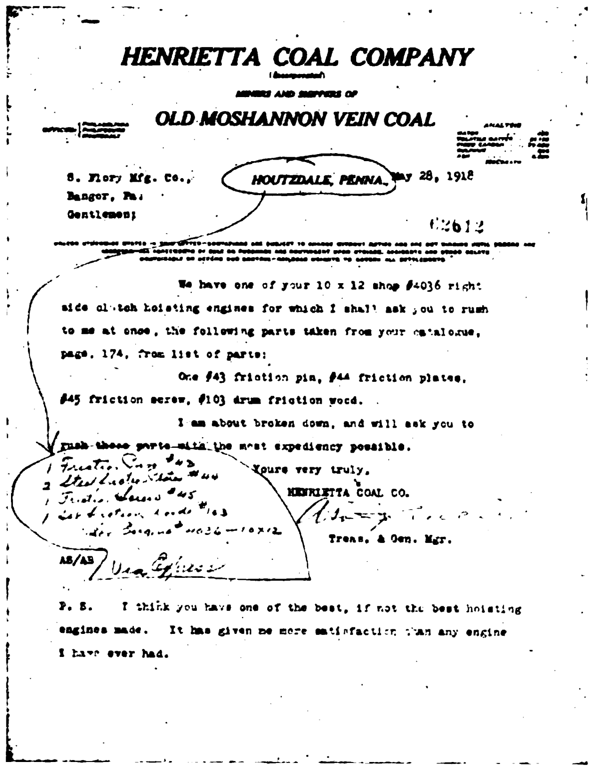

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COKE handling at Manchester Corporation Gas Works. G. F. Zimmer, *Engng.* (Oct. 4, 1918) **106**, 367. 2000 w.

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METALLURGY OF IRON AND STEEL

(See also Ore-dressing and Preparation of Coal, Coal and Coke, Metallurgy of Non-ferrous Metals)

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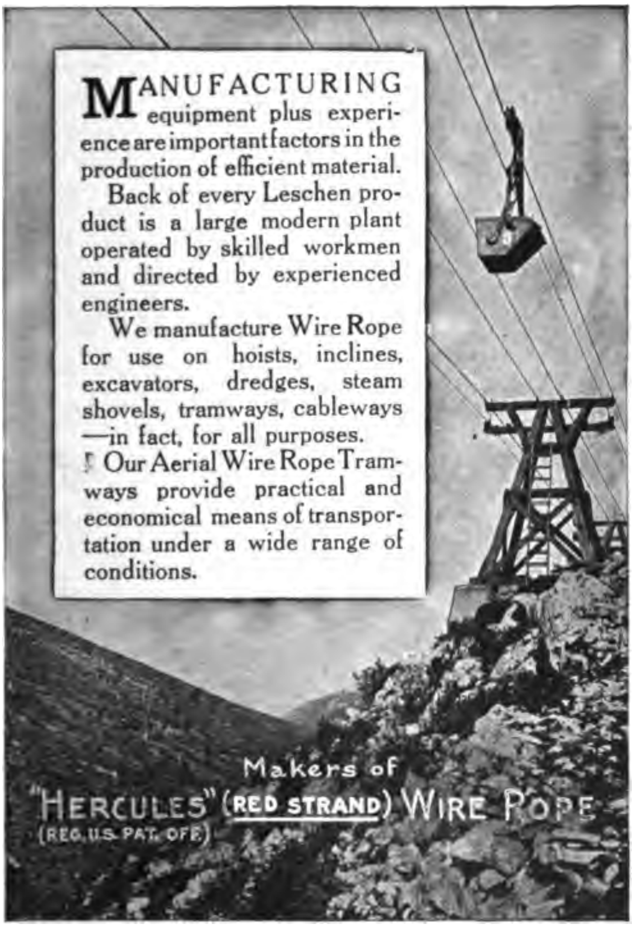

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HARDENING tyres. A. Norton, British Pat. 118920. *Ill. Off. Jnl.* (Nov. 6, 1918) 2554. 100 w.

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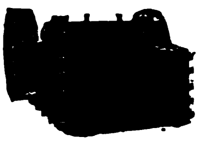

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TESTS of large bridge columns. J. H. Griffith and J. G. Bragg, *Mech. World* (Oct. 25, 1918) **64**, 197. 1200 w.

TREATING steel pieces furnace. W. R. Bennett, Canad. Pat. 185354. *Off. Rec.* (July, 1918) **46**, 2027. 600 w.

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WASTE heat from open hearth furnaces. T. B. Mackenzie, *Blast Fur. & Steel Plant* (Nov., 1918) **6**, 460–5. 3000 w. From a paper read at the British Iron & Steel Inst.

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WELDING, Fusion, fallacies. S. W. Miller, *Machy.* (Oct., 1918) **25**, 123–4. 1000 w.

WELDING steel, Difficulties of, by oxyacetylene process. B. K. Smith, *Ry. Mech. Engr.* (Nov., 1918) **92**, 628. 800 w. Abs. of paper read before Northwest Weld. Assn.

WOLFRAM ore and tungsten. *Chem. News* (Oct. 25, 1918) **117**, 337–8. 1000 w. From *Jnl.* Royal Soc. Arts, No. 3436.

METALLURGY OF NON-FERROUS METALS

(See also Mineral Resources, Ore-dressing and Preparation of Coal, Coal and Coke, and Metallurgy of Iron and Steel)

ADMIRALTY gun-metal: The influence of impurities on its mechanical properties. F. Johnson, *Prac. Engr.* (Oct. 24, 1918) **58**, 197–8. 1800 w. Serial. *Fdy. Tr. Jnl.* (Oct., 1918) **20**, 526. 600 w. Abs. of paper read before Inst. of Metals, Sept., 1918.

ALLIED Metals Congress. *Canad. Min. Jnl.* (Nov. 1, 1918) **39**, 364–5. 1000 w.

ALLOYS. British Thomson-Houston Co., Brit. Pat. 118947. *Ill. Off. Jnl.* (Nov. 6, 1918) 2564. 100 w.

ALLOYS, F. Milliken. Brit. Pat. 118825. *Ill. Off. Jnl.* (Nov. 6, 1918) 2514. 100 w.

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ALUMINUM alloy and process of making same. L. S. Gardner, Canad. Pat. 1280706. *Off. Rec.* (July, 1918) **46**, 190. 100 w.

ALUMINUM, Alloys of, with rare or special alloys. J. Escard, *Metal Ind.* [London] (Oct. 25, 1918) **13**, 273–4. 1400 w. Serial.

ALUMINUM and its alloys, their future after the war. Dr. Rosenhain, *Aeronautics* (Oct. 2, 1918) **15**, 321–2. 1900 w.

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ALUMINUM, Annealing cold rolled, sheet. R. J. Anderson, *Engng.* (Oct. 4, 1918) **106**, 388–90. 3000 w. Paper read before Inst. of Metals, Sept. 11, 1918.

ALUMINUM bronze as an engineering material. C. Vickers, *Machy.* (Oct., 1918) **25**, 135–6. 2000 w.

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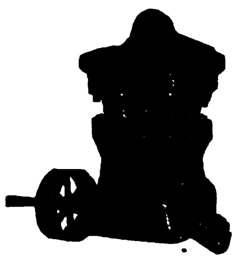

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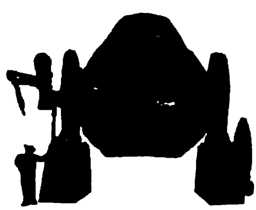

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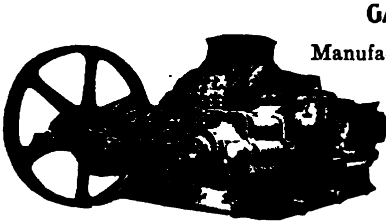

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ALUMINUM, Casting in. *Prac. Engr.* (Sept. 26, 1918) **58**, 153. 500 w.

ALUMINUM, Tests on. Essais sur l'aluminium. *Bull.* Soc. Fran. Elect. (July-Aug.-Sept.-Oct., 1918) **8**, 332–5. 700 w.

ALUMINUM, Solders for. P. D. Merica and L. F. Gurevich. *Metal Ind.* [N. Y.] (Nov., 1918) **16**, 500–3. 1600 w.

AMERICAN spirlet roasting furnace. *Min. Mag.* (Oct., 1918) **19**, 216–8. 1200 w. Abs. of paper by H. J. Harlow in *Engng. & Min. Jnl.*, Aug. 17, 1918.

ANTIMONY, Transvaal. *South Afr. Min. Jnl.* (Sept. 28, 1918) **28**, 63–4. 500 w.

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BRASS castings, Expansion and contraction of. Useful foundry information for patternmaker and founder. P. W. Blair, *Metal Ind.* (Oct. 4, 1918) **13**, 222. 500 w.

BRASSES and white metal, Separating. *Metal Ind.* [N. Y.], (Nov., 1918) **16**, 506. 300 w. From *Metall und Erz.*

CARBONIZING, Comparisons of, results. N. H. Humphreys, *Gas Jnl.* (Oct. 8, 1918) **144**, 70–1. 800 w.

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COPPER in converter slags. F. E. Lathe, *Chem. & Met. Engng.* (Nov. 15, 1918) **19**, 700–1. 500 w. Letter.

COPPER, Process of leaching, ores. A. W. Hahn, U. S. Pat. 1282415. *Off. Gaz.* (Oct. 22, 1918) **255**, 726. 300 w.

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ELECTROLYTIC process. M. M. Merritt, U. S. Pat. 1282262. *Off. Gaz.* (Oct. 22, 1918) **255**, 685. 200 w.; U. S. Pat. 1282263. **255**, 685. 100 w.

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EYRE Smelting Co., Limited. *Metal Ind.* [London] (Oct. 25, 1918) **13**, 276–7. 1200 w.

GOLD, Grease amalgamation of. H. A. White, *Engng. & Min. Jnl.* (Nov. 23, 1918) **106**, 904. 600 w.

GOLD ores, Roasting for amalgamating and cyaniding Cripple Creek sulphotelluride. J. M. Tippett, *Bull.* Am. Inst. Min. Engrs. (Nov., 1918) 1668–9. 500 w. Discussion of paper by A. L. Blomfield and M. J. Trott, A. I. M. E. *Bull.* 140, Aug., 1918.

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HERAULT furnace used for non-ferrous alloys. *Canad. Machy.* (Nov. 14, 1918) **20**, 563–5. 1000 w.

LEAD refining at Bunker Hill Plant. C. T. Rice, *Engng. & Min. Jnl.* (Nov. 2, 1918) **106**, 771–7. 3000 w.

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MELTING and re-heating furnace, New. *Fdy. Tr. Jnl.* (Oct., 1918) **20**, 543–4. 700 w.

METAL alloy. H. S. Cooper, Canad. Pat. 185436. *Off. Rec.* (July, 1918) **46**, 2057. 400 w.

METAL manufacture. F. A. Eustis, Canad. Pat. 185443. *Off. Rec.* (July, 1918) **46**, 2062. 600 w.

METAL substitute in Germany. *Brass Wld.* (Oct., 1918) **14**, 309. 700 w.

METALLURGICAL practice on Cinnabar at Idria, Austria. R. Sterner-Rainer, *Chem. & Met. Engng.* (Nov. 15, 1918) **19**, 721–7. 5000 w. Translated from Osterreichische Zeitschrift für Berg und Hüttenwesen, v. 62, 1914.

MOLYBDENUM and alloys thereof, Process of obtaining. J. A. Holladay, U. S. Pat. 1281961. *Off. Gaz.* (Oct. 15, 1918) **255**, 562. 100 w.

MOLYBDENUM. Western chemical and metallurgical field. *Chem. & Met. Engng.* (Nov. 1, 1918) **19**, 654–5. 800 w.

MONEL metal, Note on. J. Arnott, *Engng.* (Oct. 25, 1918) **106**, 451. 1000 w.

NOBEL metal alloy. G. H. Dufour, U. S. Pat. 1282055. *Off. Gaz.* (Oct. 22, 1918) **255**, 627. 100 w.

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OXYGEN and sulphur in melting of copper cathodes. S. Skowronski, *Brass. Wld.* (Oct., 1918) **14**, 281–2. 1000 w. From A. I. M. E. *Bull.*, Mch., 1918.

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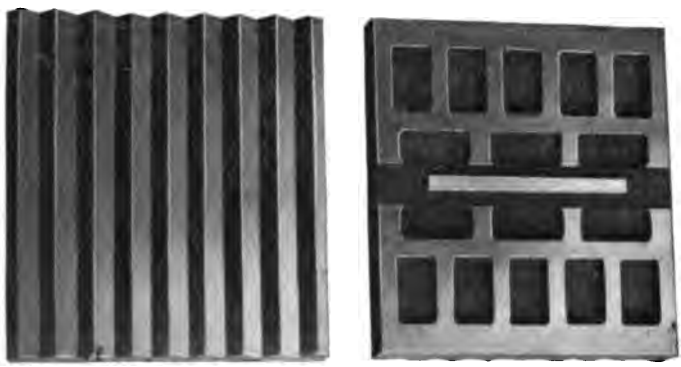

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Macleod Co., Bogen St., Cincinnati, Ohio.

Forgings, Heavy
Holmes & Bros., Inc., Robt., 30 N. Hasel St., Danville, Ill.

Fuller Mill Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Furnaces, Assay
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.
Macleod Co., Bogen St., Cincinnati, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.

Furnaces, Electric
General Electric Co., Schenectady, N. Y.
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Furnaces, Flue Welding
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Gas
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Lead
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Mechanical Roasting
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Wedge Mechanical Furnace Co., Greenwich Point, Philadelphia, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Furnaces, Muffle
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Oil
Macleod Co., Bogen St., Cincinnati, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.

Furnaces, Reverberatory
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Smelting
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Furnaces, Tire Heating
Macleod Co., Bogen St., Cincinnati, Ohio.

Gears
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Generators, Acetylene Welding and Cutting
Macleod Co., Bogen St., Cincinnati, Ohio.

Generators, Electric
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Goodman Mfg. Co., Halstead St. & 48th Place, Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Grinders, Sample
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Grizzly & Riffle Bars (For Hydraulic Mines)
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Guns, Cement
Macleod Co., Bogen St., Cincinnati, Ohio.

Guns, Concrete
Macleod Co., Bogen St., Cincinnati, Ohio.

Gyratory Crusher Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Hangers, Mine
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Hitchings Mine Car
Macomber & Whyte Rope Co., Kenosha, Wis.

Hoists, Electric
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Flory Mfg. Co., S., Bangor, Pa.
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Hoists, Skip
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Hoists, Steam
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Flory Mfg. Co., S., Bangor, Pa.
Holmes & Bros., Inc., Robt., 30 N. Hasel St., Danville, Ill.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Hoppers, Weigh
Holmes & Bros., Inc., Robt., 30 N. Hasel St., Danville, Ill.

Hose, Air
Denver Rock Drill Mfg. Co., Denver, Colo.
Goodrich Rubber Co., B. F., Akron, O.

Hydrated Ferric Oxide (For Gas Purification)
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Hydraulic Mining Machinery
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Insulators, Third Rail
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Jackets, Water
Traylor Engineering & Mfg. Co., Allentown, Pa.

Jaw Crusher Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Jigs
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Colorado Iron Works Co., Denver, Colo.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Laboratory Supplies
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Lamps, Acetylene
Macleod Co., Bogen St., Cincinnati, Ohio.

Lamps, Electric
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

CLASSIFIED LIST OF MINING AND METALLURGICAL EQUIPMENT

Lead Acetate
Heil Chemical Co., Henry, 210-214 S. 4th St., St. Louis, Mo.

Linings, Ball and Tube
Traylor Engineering & Mfg. Co., Allentown, Pa.

Linings, Brake
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Litharge
Heil Chemical Co., Henry, 210-214 S. 4th St., St. Louis, Mo.

Loaders, End
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.

Loading Booms
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Locomotives, Compressed Air
General Electric Co., Schenectady, N. Y.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Locomotives, Electric Trolley
General Electric Co., Schenectady, N. Y.
Goodman Mfg. Co., Halstead St. & 48th Place, Chicago, Ill.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Locomotives, Gasoline
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Locomotives, Steam
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Locomotives, Storage Battery
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Low Carbon Ferro-Manganese
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnesia Brick
Harbison-Walker Refractories Co., Farmers' Bank Bldg., Pittsburgh, Pa.
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnesite Cement
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnesium Metal (Ingots and Powder.)
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnetic Pulleys (See Pulleys, Magnetic)

Manganese Dioxide (Lump and Ground)
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Manganese Ore
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Meters, Electric
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Mica
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Mills, Ball, Tube and Pebble
Allis-Chalmers Mfg. Co., Milwaukee, Wis
Colorado Iron Works Co., Denver, Colo.
Fuller-Lehigh Co., Fullerton, Pa.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Mills, Chilean
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Mills, Stamp
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n. 115 Broadway, New York City.

Mine Car Hitchings (See Hitchings, Mine Car)

Molybdate of Ammonia
Primos Chemical Co., Primos, Pa.

Molybdate of Calcium
Primos Chemical Co., Primos, Pa.

Molybdate of Soda
Primos Chemical Co., Primos, Pa.

Molybdenum Metal
Primos Chemical Co., Primos, Pa.

Molybdenum Ore, Buyers of
Primos Chemical Co., Primos, Pa.

Molybdic Acid
Primos Chemical Co., Primos, Pa.

Motors, Electric
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Muffles
Mine and Smelter Supply Co., 42 Broadway, New York City.

Ore-Bedding Systems
Robins Conveying Belt Co., Park Row Bldg., New York City.

Ore Handling Machinery
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Robins Conveying Belt Co., Park Row Bldg., New York City.

Ore Milling Machinery
Colorado Iron Works Co., Denver, Colo.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Ores, Buyers and Sellers of
Beer, Sondheimer & Co., 61 Broadway, New York City.
Vogelstein & Co., Inc., L., 42 Broadway, New York City.

Oxy-Acetylene Apparatus
Macleod Co., Bogen St., Cincinnati, Ohio.

Packings, Steam
Johns-Manville Co., H. W., 296 Madison Ave., New York City.
Goodrich Rubber Co., B. F., Akron, O.

Painting Machines
Macleod Co., Bogen St., Cincinnati, Ohio.

Pipe Insulations
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Plate Metal Work
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.

Platinum Wire, Foil & Ware
Heil Chemical Co., Henry, 210-214 S. 4th St. St. Louis, Mo.

CLASSIFIED LIST OF MINING AND METALLURGICAL EQUIPMENT

Powder, Blasting
Du Pont de Nemours & Co., E. I., Wilmington, Del.

Powdered Coal Equipment
Fuller-Lehigh Co., Fullerton, Pa.

Power Transmission Machinery
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Presses, Filter
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pulleys, Magnetic
Buchanan Co., C. G., 90 West St., New York City.

Pulverizer Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Pulverizers
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Pulverizers, Coal and Coke
Fuller-Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Pulverizers, Ore
Fuller-Lehigh Co., Fullerton, Pa.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Acid
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Centrifugal
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Hydraulic Pressure
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Pneumatic Air Lift
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Pumps, Power
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Sand
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Pumps, Sinking
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Stuff
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Track
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pyrometers
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Quarrying Machinery
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Quicksilver
Beer, Sondheimer & Co., 61 Broadway, New York City.

Refractories
Harbison-Walker Refractories Co., Farmers' Bank Bldg., Pittsburgh, Pa.

Respirators
Goodrich Rubber Co., B. F., Akron, O.
Heil Chemical Co., Henry, 210–214 S. 4th St. St. Louis, Mo.

Revolving Screen Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Rock Drill Steel (See Steel, Drill)

Rods, Drill
Colonial Steel Co., Keystone Bldg., Pittsburgh, Pa.
International High Speed Steel Co., 99 Nassau St., New York, N. Y.

Roller Mill Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Rolls, Crushing
Buchanan Co., C. G., 90 West St., New York City.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Roofings, Asbestos and Rubber-type
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Rope, Wire
Leschen & Sons Rope Co., A., 920 N. 1st St., St. Louis, Mo.
Macomber & Whyte Rope Co., Kenosha, Wis.
Roebling's Sons Co., John A., Trenton, N. J.

Rope Fastenings, Wire
Macomber & Whyte Rope Co., Kenosha, Wis.
Roebling's Sons Co., John A., Trenton, N. J.

Rubber Goods, Mechanical
Goodrich Rubber Co., B. F., Akron, O.

Samplers, Ore
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Scorifiers
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Screens, Bar
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.

Screens, Perforated Metal
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Screens, Revolving
Buchanan Co., C. G., 90 West St., New York City.
Colorado Iron Works Co., Denver, Colo.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Robins Conveying Belt Co., Park Row Bldg., New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Screens, Shaking
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.

Separators, Magnetic
Buchanan Co., C. G., 90 West St., New York City.

Shaft Sinking and Development Work
Longyear Co., E. J., 710 Security Bldg., Minneapolis, Minn.

CLASSIFIED LIST OF MINING AND METALLURGICAL EQUIPMENT

Sharpeners, Drill
Denver Rock Drill Mfg. Co., Denver, Colo.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Silica Brick
Harbison-Walker Refractories Co., Farmers' Bank Bldg., Pittsburgh, Pa.

Skip Hoists (See Hoists, Skip)
Macomber & Whyte Rope Co., Kenosha, Wis.
Roebling's Sons Co., John A., Trenton, N. J.

Smelters
Beer, Sondheimer & Co., 61 Broadway, New York City.
Vogelstein & Co., Inc., L., 42 Broadway, New York City.

Smelting Machinery
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Soda Ash
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Spelter
Illinois Zinc Co., Peru, Ill.

Spiegeleisen
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Sprockets
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Stamp Mill Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Steel, Crucible
Colonial Steel Co., Keystone Bldg., Pittsburgh, Pa.

Steel, Drill, Hollow and Solid
Colonial Steel Co., Keystone Bldg., Pittsburgh, Pa.
Denver Rock Drill Mfg. Co., Denver, Colo.
International High Speed Steel Co., 99 Nassau St., New York, N. Y.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Steel, Tool
Colonial Steel Co., Keystone Bldg., Pittsburgh, Pa.
International High Speed Steel Co., 99 Nassau St., New York, N. Y.

Stokers
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Switchboards
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Tables, Concentrating (See Concentrators)

Test Lead
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Thawers, Switch
Macleod Co., Bogen St., Cincinnati, Ohio.

Thermometers
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Thickeners, Slime
Colorado Iron Works Co., Denver, Colo.
Dorr Co., Denver, Colo.

Tipple Machinery Equipment
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Torches, Cutting and Welding
Macleod Co., Bogen St., Cincinnati, Ohio.

Towers and Bridges, Stocking and Reclaiming
Robins Conveying Belt Co., Park Row Bldg., New York City.

Tramways, Wire Rope, Aerial
Leschen & Sons Rope Co., A., 920 N. 1st St., St. Louis, Mo.
Macomber & Whyte Rope Co., Kenosha, Wis.
Roebling's Sons Co., John A., Trenton, N. J.

Transformers, Electric
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Traps, Steam
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Tungstate of Ammonia
Primos Chemical Co., Primos, Pa.

Tungstate of Soda
Primos Chemical Co., Primos, Pa.

Tungsten Metal
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.
Primos Chemical Co., Primos, Pa.

Tungsten Ore
Lavino and Co., E. J., Bullitt Bldg., Philadelphia. Pa.

Tungsten Ore, Buyers of
Primos Chemical Co., Primos, Pa.

Tungstic Acid
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.
Primos Chemical Co., Primos, Pa.

Turbines, Hydraulic
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Turbines, Steam
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Valves, Pump
Goodrich Rubber Co., B. F., Akron, O.

Vanadate of Ammonia
Primos Chemical Co., Primos, Pa.

Vanadic Acid
Primos Chemical Co., Primos, Pa.

Vanadium Chloride
Primos Chemical Co., Primos, Pa.

Vanadium Ore, Buyers of
Primos Chemical Co., Primos, Pa.

Ventilating Fans (See Fans, Ventilating)

Wagon Loaders
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Weigh Hoppers (See Hoppers, Weigh)

Wheels
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Wheels, Mine Car
Fuller-Lehigh Co., Fullerton, Pa.

Wire, Iron, Steel and Copper
Roebling's Sons Co., John A., Trenton, N. J.

Wire Mechanism (Lever Control)
Gwilliam Co., 253 W. 58th St., New York City.

Wire Rope (See Rope, Wire)

Wires and Cables, Electrical
General Electric Co., Schenectady, N. Y.
Goodrich Rubber Co., B. F., Akron, O.
Roebling's Sons Co., John A., Trenton, N. J.

Zinc Dust
Vogelstein & Co., Inc., L., 42 Broadway, New York City.

Zinc Sheet
Illinois Zinc Co., Peru, Ill.

PROFESSIONAL CARDS

ALPHABETICAL LIST OF ADVERTISERS

(With Summary of Products)

See pages 36–48 *for Classified List of Mining and Metallurgical Equipment*

* Advertisement does not appear in this issue, but products are listed in Classified List of Mining and Metallurgical Equipment.

ALPHABETICAL LIST OF ADVERTISERS (Continued)

* Advertisement does not appear in this issue, but products are listed in Classified List of Mining and Metallurgical Equipment.

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for Less Coal—

plus continuous, year in, year out service, **plus** floor space and foundation savings, **plus** economy in care and repair may be looked for if you choose—

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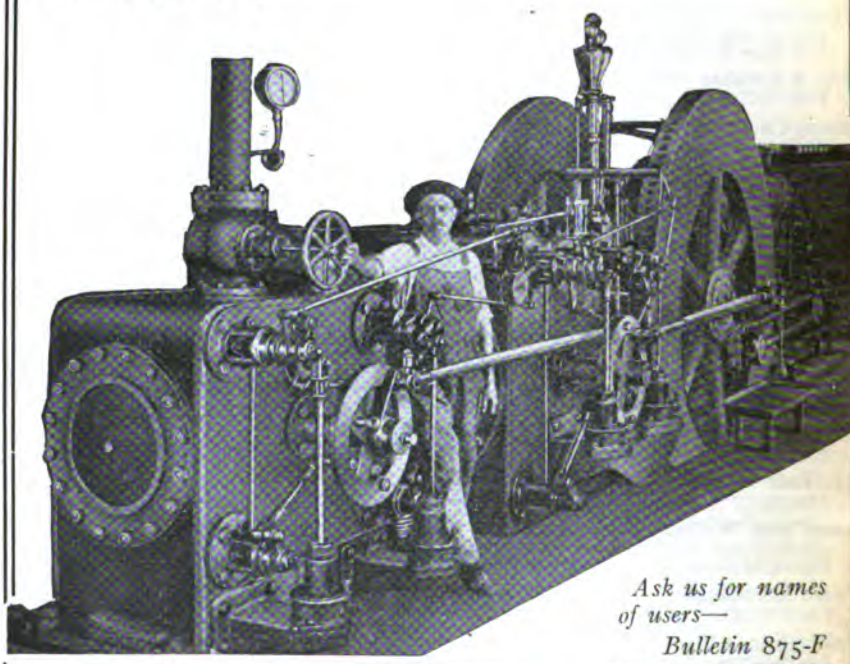
In these machines, high duty is secured by the use of tandem compound steam cylinders, both equipped with full Corliss valve gear. The point of cut-off is varied automatically by a combined speed and air pressure regulator of great sensitiveness.

Tandem, two-stage air cylinders, with large intercooling area provide high volumetric and compression efficiencies. Capacities, 1000 to 3150 cu. ft.



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Bulletin 875-F

SULLIVAN MACHINERY CO.

122 South Michigan Avenue, Chicago, Ill.

30 Church Street, New York.

No. 146 February 1919

Bulletin of the American Institute of Mining Engineers

with which is consolidated the

American Institute of Metals

SPECIAL FEATURES

PUBLISHED MONTHLY

(*Frontispiece*)

Rossiter Worthington Raymond

Bulletin of the American Institute of Mining Engineers

WITH WHICH IS CONSOLIDATED THE

American Institute of Metals

No. 146 FEBRUARY 1919

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ADVERTISING

BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS

WITH WHICH IS CONSOLIDATED THE

AMERICAN INSTITUTE OF METALS

No. 146 FEBRUARY 1919

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ROSSITER WORTHINGTON RAYMOND, Ph. D., LL. D.—1840 TO 1918

Dr. Rossiter W. Raymond, Past President, Honorary Member, and Secretary Emeritus, died suddenly of heart failure at his home, 123 Henry St., Brooklyn, N. Y., on the evening of Tuesday, Dec. 31, 1918. He is survived by his wife and daughter. He was one of the founders of the Institute and its second President, his genius was the Institute's guiding spirit for 47 years.

Dr. Raymond was one of the most versatile men of the day; an able mining engineer; brilliant professional writer; an editor of the first rank and an acknowledged authority on matters of literary style; a creator in the fields of fiction, children's stories, poetry and music; for more than 50 years the superintendent of Plymouth Church Sunday School. He will be revered by thousands as a loyal friend, generous giver, and admired colleague. His passing marks an epoch in mining and metallurgical literature. A memorial service will be held in the Auditorium of the Institute Headquarters on Monday, Feb. 17, 1919, at 4.30 P.M.

SUMMARY OF PROGRAM FOR NEW YORK MEETING

MONDAY, FEB. 17

9.00 A.M. to
9.00 P.M. Registration at Institute Headquarters.
9.00 A.M. Meeting of Committee on Development of the Activities of the Institute, Room 905, 9th Floor.
10.00 A.M. Simultaneous Sessions of
Institute of Metals Division, Room 2, 5th floor.
Industrial Organization, Room 1, 5th Floor.
12.30 P.M. Luncheon at Headquarters, 5th Floor.
2.00 P.M. to
4.25 P.M. Simultaneous Sessions of
Institute of Metals Division, Room 2, 5th Floor.
Industrial Organization, Room 1, 5th Floor.
Petroleum and Gas, Room 905, 9th Floor.
2.30 P.M. Sightseeing trip by automobile for the ladies. Among the points visited will be:
The American Museum of Natural History.
The Episcopal Cathedral of St. John the Devine.
The Spanish Museum.
The American Geographical Society.
The American Numismatic Society.
The visits will be followed by Tea.
4.30 P.M. Memorial Service to Dr. Rossiter W. Raymond, Auditorium.
8.30 P.M. Smoker, 5th floor.

TUESDAY, FEB. 18

Canadian Mining Institute Day

9.30 A.M. Annual Business Meeting of A. I. M. E.
10.00 A.M. Simultaneous Sessions on
Principles of Mine Taxation, Improved Relations of Capital and Labor, Auditorium, 3d Floor.
Iron and Steel, Room 1, 5th Floor.
11.00 A.M. Meeting of the Woman's Auxiliary, Room 2, 5th Floor.
12.00 P.M. Meeting of the Board of Directors, Room 905, 9th Floor.
12.30 P.M. Luncheon at Headquarters, 5th Floor.
1.00 P.M. The Directors will entertain at Luncheon at the Engineers' Club, officers of Canadian Mining Institute and other distinguished visitors.
2.30 P.M. to
5.00 P.M. Discussion of International Coöperation in Mining in North America, Auditorium.
Uniform Mining Law for North America, Auditorium.
2.00 P.M. Sessions on Iron and Steel, Room 905, 9th Floor.
3.00 P.M. Visit to Senator Clark's Galleries and Metropolitan Museum of Art.
4.30 P.M. Memorial Meeting for Members Who Died in Service.
8.30 P.M. Evening Entertainment and Dancing, Auditorium, 3d Floor.

WEDNESDAY, FEB. 19

9.00 A.M. Committee on Development, Room 3, 5th Floor.
10.00 A.M. Simultaneous Sessions of
National Research Council, Room 1, 5th Floor.
Mining, Milling, and Geology, Room 2, 5th Floor.
11.00 A.M. Meeting of Woman's Auxiliary, Room 905, 9th Floor.
12.30 P.M. Luncheon at Headquarters, 5th Floor.
2.30 P.M. Matinee for the Ladies.
2.30 P.M. to
5.00 P.M. Joint Session with American Institute of Electrical Engineers on Electric Welding, Auditorium.
2.30 P.M. to
5.00 P.M. Moving pictures showing operations of New Cornelia Mining Co.; mining operations of the Utah Copper Co., and Nevada Consolidated Copper Co.; milling operations of the Utah Copper Co.; and smelting operations of the Garfield Smelting Co., Room 1, 5th Floor.
6.30 P.M. President's Reception, Hotel Biltmore.
7.30 P.M. Annual Banquet followed by Dancing, Hotel Biltmore.

THURSDAY, FEB. 20

All-day excursion to Federal Ship Building Plant, Newark, N. J. Inspection of steel ship being electrically welded throughout. Tickets must be obtained in advance at Registration Bureau.

A ship launching has also been arranged.

NEW YORK HOTEL RATES FOR THE FEBRUARY MEETING

Name	Location	Rooms With Bath		Rooms Without Bath	
		Double	Single	Double	Single
Algonquin	52 West 44th St.	$4.00	$3.00		
Astor	Times Square, 43d St. and Broadway	5.00 up	4.00 up	$4.00	$2.50 up
Belmont	42d St. and Park Ave.	6.00 up	5.00 up	5.00	3.00 up
Biltmore	43d St. and Madison Ave.	6.00 up	5.00 up	4.00 up	3.00 up
Breslin	29th St. and Broadway	5.00 up	2.50 up	4.00 up	2.00 up
Grand	31st St. and Broadway	2.50 up	1.50 up	2.00 up	1.00 up
Hermitage	42d Street and Broadway	4.50 up	2.50 up	3.50 up	2.00 up
Imperial	32d St. and Broadway	4.50 up	3.00 up	3.50 up	2.50
Knickerbocker	42d St. and Broadway	5.00 up	3.50 up	4.00 up	2.50 up
McAlpin	34th St. and Broadway	4.00 up	3.00 up	3.50 up	2.50 up
Manhattan	42d St. and Madison Ave.	6.00 up	4.00 up	4.50 up	3.00 up
Martinique	32d St. and Broadway	4.00 up	3.00 up	3.00 up	2.00 up
Monticello	35 West 64th St.	2.50 up	2.00 up		
Navarre	38th St. and Seventh Ave.	3.00 up	1.50 up	2.50 up	1.50 up
Plaza	58th St. and Fifth Ave.	6.00 up	4.00 up		
Prince George	28th St. and Fifth Ave.	3.00 up	2.00 up		
Seville	29th St. and Madison Ave.	4.00 up	2.50	3.50	2.00
Waldorf-Astoria	34th St. and Fifth Ave.	6.00 up	4.00 up	5.00 up	3.00 up
Wolcott	4 West 31st St.	4.00 up	3.00 up	3.00 up	2.00 up
York	36th St. and Seventh Ave.	3.50	2.50 up	2.50	1.50

REPORTS FOR THE YEAR 1918

THE SECRETARY'S REPORT

Rossiter Worthington Raymond, Ph.D., LL. D—1840 *to* 1918.—Dr. Rossiter W. Raymond, Past President, Honorary Member and Secretary Emeritus, died suddenly of heart failure at his home, 123 Henry St., Brooklyn, N. Y., on the evening of Tuesday, Dec. 31, 1918. He was one of the founders of the Institute and its second President. A Memorial Service will be held on Monday afternoon, Feb. 17.

James Douglas.—The Institute suffered a second very severe loss by the death of Dr. James Douglas, Honorary Member, Past President (having served as President for two years), and in three separate respects the greatest benefactor of the Institute: first, in raising funds by voluntary subscription and his own personal gifts to pay the Institute's share of the money owed on the land on which the Engineering Societies Building now stands; second, as original donor to Engineering Societies Library; and third, by his bequest of $100,000 for the maintenance of the library of the American Institute of Mining Engineers.

A resolution regarding the death of Dr. Douglas was passed by the Board of Directors and at the meeting of the Institute on September 4, 1918, in Colorado, at which time a memorial service was held in the theater of the Hotel Broadmoor, attended by about 400 members and guests. A copy of the resolution was prepared and sent to the family. A bronze tablet is now being prepared and will be placed in the Members' Room and unveiled at the February meeting. A biography and portrait of Dr. Douglas was published in the September, 1918, *Bulletin*. There is also placed in the Engineering Societies Library an oil portrait of Dr. Douglas which had his own approval and was presented by him.

American Institute of Metals.—During the Spring of the year, plans were completed with the American Institute of Metals whereby this society became the Institute of Metals Division of the American Institute of Mining Engineers. This body was a dignified aggregation of metallurgists which had been in existence for about 11 years. A bronze tablet commemorating the American Institute of Metals is now being placed in the Members' Room of the Institute, and during the year 1919 the *Bulletin* will bear the following title: "Bulletin of the American Institute of Mining Engineers, with which is consolidated the American Institute of Metals."

Visits to Local Sections.—During the year President Jennings made visits to six of the Local Sections, on three of which occasions he was accompanied by the First Vice-president and the Secretary. First Vice-president Goodale made five visitations and the Secretary made eight.

At Washington, D. C., a Local Section of the Institute was formed at a meeting held on June 21, 1918, and is described in the August *Bulletin*. There has also been a request received for the formation of a section in the Lake Superior region, to be known as The Upper Peninsula Section. The President of the Institute, accompanied by Mr. Horace V. Winchell and the Secretary, visited the members of Duluth, Minn., and Houghton, Mich., on their return from the Colorado Meeting.

Meetings.—Three meetings were held during the year; namely, the Annual Meeting in February, a full account of which is given in the *Bulletin* for April; The Colorado Meeting in September, described in the October *Bulletin;* and the Milwaukee Meeting in October, described in the November *Bulletin.*

Expulsion of Enemy Aliens.—All enemy aliens were expelled from the Institute. This included Honorary Members and those in enemy countries as well as all persons residing in other countries and known to be enemy aliens. The Committee on Membership was requested to report regarding the latter class of persons.

Remission of Dues of Men in the Service.—By action of the Board of Directors the dues of all Members, Associates, or Junior Associates in the service of the United States or its Allies were remitted upon receipt of request.

Remission of Dues of Older Members.—By action of the Board of Directors the dues were remitted of certain members who had paid dues for the past 30 years and had attained the age of 70 years. In individual cases, the dues were remitted of members who had not yet attained the age of 70 years but who had paid dues for 35 years or more and were no longer active.

Membership, Finance, Publications, Library.—The details as to the activities during the year of the Committees on Membership, Finance, Papers and Publications, and Library of the Institute are set forth in the reports of the appropriate committees given elsewhere in this *Bulletin.*

Canadian Mining Institute.—To strengthen the bonds of friendship and coöperation that have always existed between the Canadian Mining Institute and the American Institute of Mining Engineers, members of the Canadian Mining Institute not residing in the United States were privileged to subscribe to the *Bulletin* of this Institute at one-half the regular subscription price. This is the same price at which it is sold to members of the American Institute of Mining Engineers. Furthermore, the members of the Canadian Mining Institute were all invited to attend the 119th meeting of the Institute, and Feb. 18, 1919, will be known as "Canadian Mining Institute Day" at this meeting. Returning the courtesy, all members of the American Institute of Mining Engineers are invited to attend the meeting of the Canadian Mining Institute on Mar. 6, 1919, which day will be known as "American Institute of Mining Engineers Day."

Employment Department.—Employment activities of the Institute during 1918 have been on an important scale. Owing to the shortage of engineers, it has been difficult to fill all positions that were open. This situation was reversed on the signing of the armistice, when a great many engineers were discharged from the service. Coöperation with the Government Department was maintained through a committee of Engineering Council. In November, this Committee was superseded by a bureau of employment headed by the Secretaries of the Four Founder Societies, which bureau is now known as the Engineering Societies Employment Bureau. This Bureau is also coöperating with the United States Employment Service, maintained by the United States Department of Labor. At the time of this writing (January, 1919), the supply of engineers returning from the war is very much larger than the number of situations offered.

National Research Council.—With the approval of the President, in May, 1918, the Secretary assumed the duties of Chairman of the Section on Metallurgy of the Engineering Division of the National Research Council. In this way the Institute was enabled to be of service to the National Research body in connection with many problems in metallurgy for the benefit of the Army, Navy, Aircraft Board, Emergency Fleet Corporation, and other war activities. At the 119th meeting of the Institute, in February, 1919, nine papers on metallurgy will be presented, all of which are reports of researches under the auspices of National Research Council.

The National Research Council was originated in 1916 at the request of the National Academy of Science. On May 11, 1918, National Research Council was made a permanent body by executive order of the President of the United States. The President and Secretary of the Institute joined with the Presidents and Secretaries of the other Founder Societies in giving a dinner to the Chairman and officers of the National Research Council, at the Engineers' Club. In this way the Institute has been performing one of the important objects of its incorporation, namely, the promotion and encouragement of engineering research.

COMMITTEE ON MEMBERSHIP

The total number of applications brought before the Committee during the year 1918 was 675; the total number of persons who were elected and became members of the Institute during the same period was 666.

The total membership of the Institute on Dec. 31, 1917, was 6528, consisting of 20 Honorary Members, 5832 Members, 237 Associates, and 439 Junior Associates. The changes in membership during the year are shown in the accompanying schedule:

Total Membership, Dec. 31, 1917	...	6528
Loss by resignation	60	
Loss by suspension	162	
Loss by death	90	312
		6216
Elected	666	
Reinstated	56	
By affiliation with American Institute of Metals	220	942
Membership, Dec. 31, 1918	...	7158
Change of Status:		
Associates to Members	1	
Junior Associates to Associates	8	
Junior Associates to Members	21	

REPORT OF TREASURER AND FINANCE COMMITTEE

To the Chairman and Members of the Finance Committee:

We have audited the books and accounts of the American Institute of Mining Engineers and have prepared therefrom a statemtnt of cash receipts and disbursements for the year ended December 31, 1918, and a balance sheet at the latter date. A summary of cash receipts and disbursements follows:

January 1, 1918—Balance in banks and on hand....	$ 10,465.13
December 31, 1918—Receipts for the year..........	112,298.19
	$122,763.32
Deduct: Disbursements for year..................	114,504.95
December 31, 1918—Balance on hand..............	$8,258.37

Distributed as follows:

National Bank of Commerce......................	$1,093.09
Brooklyn Trust Company.........................	4,261.51
Fifth Avenue Bank of New York..................	2,249.66
Fifth Avenue Bank of New York (special account)...	454.11
Petty cash in office............................	200.00
	$8,258.37

During the year investment was made in $2000 United States Government 4¼ per cent. Third Liberty Loan Bonds due 1928. Of this amount $650 was used as a further investment on account of the Life Membership Fund and $1250 was purchased by employees and $100 is held in the safe.

We examined the securities as set forth in the balance sheet and found them as there stated. The market values as at December 31, 1918, as quoted by Messrs. Lee, Higginson & Company, are shown below:

$2,000 Interborough Rapid Transit 5 per cent. bonds due 1966 @ 72..	$1,440.00
$1,000 Illinois Central, Chicago, St. Louis & New Orleans 5 per cent. bond due 1963 @ 94......................	940.00
$2,000 Chicago, Milwaukee & St. Paul R. R. 4 per cent. bonds due 1934 @ 76..............................	1,520.00
$1,000 Chicago, Milwaukee & St. Paul 4½ per cent. bond due 2014 @ 72....................................	720.00
$650 United States Government Third Liberty Loan 4¼ per cent. due 1928 @ 96..............................	624.00

A further payment of $2500 was made during the year on account of the Institute's proportion of the cost of the addition to Engineering Building leaving a balance of $5000 still unpaid.

The change in valuation of the equity of the American Institute of Mining Engineers in the United Engineering Society land and building is made by the Finance Committee, on our recommendation, the total valuation having been obtained from the United Engineering Society and shown on the books of the American Institute of Mining Engineers at one-fourth of this total figure. This change was brought about by the admission of one additional Founder Society. The same method, we understand, has been adopted by at least one of the other Founder Societies.

Vouchers and cancelled checks were produced for all cash disbursements. The cash on hand was counted and found correct and certificates obtained verifying the bank balances.

All cash received as shown by the books was deposited to banks. The footings and postings to general ledger were checked and found correct.

We are pleased to state that we find the books well kept and the records of the Institute in good order.

Yours very truly,

Barrow, Wade, Guthrie & Co.

REPORT OF TREASURER AND FINANCE COMMITTEE

ASSETS

Cash on Hand and in Banks:		
General funds	$6,752.27	
Special funds	1,506.10	8,258.37
Investment of Life Membership Fund:		
$2,000 Interborough Rapid Transit 5 per cent. bonds 1966	$1,974.31	
$1,000 Illinois Central, Chicago, St. Louis & New Orleans 5 per cent. bonds due 1963	1,010.56	
$2,000 Chicago, Milwaukee & St. Paul R. R. 4 per cent. bonds due 1934	1,877.63	
$1,000 Chicago, Milwaukee & St. Paul 4½ per cent. bond due 2014	824.25	
$650 U. S. Government Third Liberty Loan 4¼ per cent. due 1928	650.00	6,336.75
Liberty Bond:		
$100 U. S. Government Third Liberty Loan 4¼ per cent. due 1928		100.00
Interest in United Engineering Building:		
Land and building 29 West 39th Street—¼ of $1,947,171.16		486,792.79
Library:		
Books and periodicals in Library belonging to American Institute of Mining Engineers		40,000.00
		$541,487.91

RECEIPTS

Initiation Fees		$6,000.00	
Annual Dues:			
Current dues	$66,135.43		
Arrears	2,321.14		
Advance	1,706.86	70,163.43	76,163.43
Receipts from Other Sources:			
Sale of transactions		$4,673.75	
Sale of binding		11,997.15	
Sale of advertising		10,448.96	
Sale of special editions		794.02	
Sale of bulletins and pamphlets		3,060.90	
Sale of pins and fobs		237.55	
Interest on Investments and Bank deposits		957.23	
Sundry refunds from Societies		269.57	
Sundry refunds from members		950.24	
Sundry receipts		213.99	33,603.36
Special Funds:			
Life memberships		450.00	
Liberty Bonds purchased by employees		1,250.00	
Proceeds from sale of Dr. Williams's book "The Diamond Mines of South Africa"		776.82	
From the Dinner Committee		19.00	
Hadfield prize—interest		33.87	
Thayer prize—interest		1.71	2,531.40
Total receipts			$112,298.19
Cash on Hand January 1, 1918			10,465.13
			$122,763.32

LIABILITIES

Special Funds:			
Hadfield prize and interest		$1,154.51	
Thayer prize and interest		58.14	
Dinner committee		115.20	
Dr. William's Book		15.00	1,342.85
Reserve for Life Membership Fund			40,000.00
Life Membership Fund:			
Balance January 1, 1918		$6,150.00	
Additions during year 1918		450.00	6,600.00
United Engineering Society:			
Balance due additions to building $12,500, less $7,500 paid			5,000.00
Surplus:			
As at January 1, 1918		$546,924.13	
Deduct:			
Adjustment of equity in land and building as authorized by chairman of Finance Committee due to one additional founder society being taken in and sharing in the equity		59,053.83	
		$487,870.30	
Add:			
Net income year 1918		674.76	488,545.06
			$541,487.91

DISBURSEMENTS

General Funds:			
Bulletin		$30,750.08	
Year Book		2,185.02	
Transactions of 1917	$1,490.42		
Transactions of 1918	7,697.07	9,187.49	
Binding transactions 1917	$ 277.57		
Binding transactions 1918	8,220.14	8,497.71	
Special editions		2,036.43	
Editorial and office		27,399.27	
Treasurer		1,154.27	
Library		3,999.97	
Advertising		5,454.01	
Meetings		3,705.88	
Local sections		2,898.54	
Technical committees		58.22	
Committee on increase of membership		2,118.11	
Back volumes 1–53—binding, etc		1,813.59	
Circulars		452.76	
Engineering Council		4,000.00	
Delegate to Council of Engineers, Paris		1,500.00	
Sundry charges to members (to be refunded)		747.54	
Pins and fobs		164.95	
Sundry disbursements		968.19	
		$109,092.03	
Addition to Engineering Building: Payment on account		2,500.00	111,592.03
Special Funds:			
Liberty bonds purchased for investment and for employees		$2,000.00	
Proceeds sale of Dr. Williams's book donated to American Red Cross Society		761.82	
Dinner Committee		151.10	2,912.92
Total Disbursements			$114,504.95
Cash on Hand December 31, 1918			8,258.37
			$122,763.32

COMMITTEE ON PAPERS AND PUBLICATIONS

During the past year 130 papers were submitted to the Committee and 107 were accepted and printed in the Bulletin. The aim of the Committee has been, not only in the acceptance of the technical papers but also in the selection of the other matter, to make the Bulletin of great interest and value to the members. To carry out this work it has been necessary for the Committee to ask many members to give considerable time to the work of the Institute, which all have freely done. This coöperation has been a great factor in the success attained by our meetings and publications.

For the 116th meeting, held in New York last February, 64 papers were received of which 50 were accepted and printed. Of the 57 submitted for the 117th meeting, held in Colorado last September, 42 were accepted and printed. All of the papers submitted for the 118th meeting, held in Milwaukee in October, 15 in number, were accepted and printed. For the 119th meeting, to be held in New York, February 17 to 20, 58 papers have been submitted, 50 of which have been accepted and printed.

In addition Volumes LVII, LVIII, and LIX of the Transactions were printed and sent to the members. Also the collective index of Volumes XXXVI to LV inclusive, which was prepared during 1917, was printed.

LIBRARY COMMITTEE

In accordance with the requirements of By-Law LX, the report of the Library Committee is herewith appended.

The total accessions of the Library for the year were as follows: Gifts, 16,258; purchase, 663; total 16,921. All of this material has been examined and cataloged and is ready for the use of readers.

The largest single gift received during the year, comprising about 800 pieces, was a library of electrical literature presented jointly by the Westinghouse Electric & Manufacturing Co. and the General Electric Co., which the United Engineering Society has agreed to keep intact for five years.

It is proposed to recatalog all the books in the library as soon as practicable.

By the will of Dr. James Douglas, the Institute was the legatee of $100,000 for the maintenance of the Library. Arrangements have been made to turn this money into the treasury of the United Engineering Society for the use of the General Library.

The attendance in the Library showed a total for the year of 15,063, which is more than 1000 over any previous record.

Engineering Index.—Among the many plans for increasing the usefulness of the Library, it has been proposed to publish an index of mining and metallurgical literature, which was started in the September, 1918, *Bulletin* of the Institute.

Sale of Publications.—The return from the sale of volumes during the year amounted to $4673.75; special editions, $794.02; and *Bulletins* and pamphlets, $3060.90. Volumes XXXI, LI, and LII have all been sold and very few copies are in stock of Volumes IX, XIV, XVII, and LII. The special edition of the Posepny volumes has also been exhausted.

MEETING OF THE BOARD OF DIRECTORS, DEC. 20, 1918

The President was authorized to appoint a liaison committee to coöperate with the American Mining Congress in respect to the establishment of a Secretary of Mines and Mining in the President's Cabinet. He appointed Edwin Ludlow, Chairman; Mark L. Requa, and J. E. Johnson, Jr.

It was resolved to accept the invitation from the Chicago Section to hold the 120th meeting of the Institute in Chicago during the week of Sept. 15, 1919.

The action of the Executive Committee in appointing Past President E. Gybbon Spilsbury as representative of this Institute to visit France upon the invitation of the Société des Ingénieurs Civils de France was approved.

The final budget for 1918 was approved.

The President was authorized to appoint a committee, of three members, on the Development of Activities of the Institute. The committee was requested to report at the February meeting of the Institute, and the Secretary was requested to invite each local section to have a member present to discuss the subject. The President appointed J. W. Richards, Chairman; P. N. Moore, and Allen H. Rogers.

Thirty-six members, ten associates, and five junior associates were elected; one change of status from associate to member was granted; two members were reinstated; and eight resignations were accepted. An extension of time was granted to nine members. The dues of eight members were suspended on account of their being in active service.

The report of the United Engineering Society's Trustees was presented in writing and was accepted and ordered filed.

The Finance Committee was appointed as the Auditing Committee.

The sum of $50 was appropriated for the Annual Table of Physical and Chemical Constants.

Charles H. MacDowell was appointed to succeed himself as representative of this Institute on the Washington Award Commission.

An exchange of Transactions was authorized with the British Institute of Metals whereby the price of our Transactions bound in half morocco is reduced to $5 per volume to any member of that Institute in consideration of their making the price of $5 per volume for their Transactions to any member of our Institute.

The Secretary was authorized to publish the Year Book after the Annual Meeting and not later than May.

LOCAL SECTION NEWS

BOSTON SECTION

ALFRED C. LANE, *Chairman*, GEORGE A. PACKARD, *Vice-chairman*,
H. M. BOYLSTON, *Secretary-Treasurer*,
R. L. AGASSIZ, FRED W. DENTON.

The forty-ninth meeting of the Boston Section was held at the Boston City Club on Monday evening, Dec. 23, 1918. The meeting was preceded by an informal dinner at which 29 members and guests were present; three or four others came in later. The reading of the minutes of the previous meeting was dispensed with by consent.

Chairman A. C. Lane introduced the speaker of the meeting, Mr. E. P. Mathewson, of New York, who gave some of his experiences in the field of copper metallurgy, including many amusing anecdotes. He told of his early work as an assayer and the difficulties he encountered in Pueblo, Mexico, and Chile. When describing the gradual increase in size of the reverberatory and copper blast furnace he said that in the early days the manager and the mason would reach the spot where a furnace was to be built, the manager would carelessly throw a brick about 20 ft., and tell the mason to "build her up to about there." He then spoke of the introduction of oil and powdered coal as fuels, and of the recent developments of the latter fuel in connection with blast furnaces, and dwelt at some length on the fume abatement problems, the wonderful results obtained from the Cottrell electric precipitation process, and on the recovery of the rarer elements in the ores, such as bismuth, arsenic, selenium, tellurium, thallium, and cadmium. Questions were asked and discussion entered into by Messrs. F. C. Newton, C. W. VanLaw, R. M. Draper, L. M. Kniffin, A. C. Lane, and others. Mr. John H. Allen, a member of the Institute, Mr. Mathewson's first employer, and other early associates in the industry were present.

A. M. BOYLSTON, *Secretary.*

SAN FRANCISCO SECTION

ROY H. ELLIOTT, *Chairman*, T. A. RICKARD, *Vice-chairman*,
W. H. SHOCKLEY, *Secretary-Treasurer*, 959 Waverley Street, Palo Alto, Cal.
D. M. RIORDAN, C. F. TOLMAN, JR.

The meeting of December 10, 1918, was held at the Engineers' Club; 33 persons were present at the dinner and 50 at the meeting. Chairman Elliott gave an account of the work of the Joint Council of the Engineering Societies of San Francisco and spoke specially of the licensing bill for engineers that is to be presented to the California legislature in 1919. Charles Butters told of the benefits of the licensing system for engineers as seen by him in South Africa and in London. A motion was carried that the present committee continue to act with the Joint Council for the coming year.

The event of the evening was the exhibition of the moving pictures of the Ajo and Inspiration properties in Arizona; we owed these to the liberality of Dr. L. D. Ricketts, who had them taken and explained some of the features that were not fully covered by the legends on the films. Mining and metallurgical operations were shown in great detail as wel* as welfare work and the extensiv war gardens—these hav a national reputation and are mentioned with commendation in "Food and the War," a book publisht by the U. S. Food Administration. The pictures are of great interest to any intelligent spectator and are of superlative value to the engineering student. We learn that they are soon to be shown in Stanford and it is hoped that arrangements may be made by which engineering students in all parts of the country may see them.

The Ajo pictures showed the workings (by leaching) of a 50,000,000-ton deposit of 1.5 per cent. copper ore. The novel monster that digs out the leached ore reminds one of the fearsome dragons of fairyland. The arrangement of the 5000-ton plant is the result of the intensiv study of

* Reformed spelling retained by special request of Secretary of San Francisco Section.

many able engineers over a long period. First a 1-ton plant was built, then a 40-ton plant was run for 14 mo. But even after this experience, the jump to a 5000-ton works was considered something of a leap in the dark and great relief was felt when it workt according to theory.

Even more interesting than the Ajo pictures were those of the 18,000-ton Inspiration works (these are said to have cost $14,000,000 before any copper was produced). The views of underground mining are said to be the best ever taken. Curiously enuf, the system of running drifts under the ore, thus cutting out the ground until the 70-ft. thick orebody caves, is practically the same as that used by the Chinese coal miners for hundreds of years in Shansi. But there is a difference in the size of the operations, for the Chinese blocks are but 50 ft. square, while at the Inspiration the cave covers 10 acres. The tipples, dumping five 5-ton cars at once and the automatic hoists raising 18,000 tons daily from two shafts (in an emergency one shaft hoisted 28,000 tons daily for 10 days) were among the most interesting of the views.

W. H. SHOCKLEY, *Secretary-Treasurer.*

COLUMBIA SECTION

J. C. HAAS, *Chairman* W. J. HALL, *Vice-chairman,*
LYNDON K. ARMSTRONG, *Secretary-Treasurer,* 720 Peyton Bldg., Spokane, Wash.
W. H. LINNEY J. F. MCCARTHY

The eighth annual meeting of Columbia Section was held in Spokane, Wash., Dec. 23, 1918. About 25 members and one guest were present, the small attendance being due to the continued poor health conditions.

Letters and telegrams were read from Chairman, S. S. Fowler, S. A. Easton, J. C. Heilman, C. G. Grant, Rush J. White, H. R. vanWagenan, Preston Locke, C. A. Wright, J. W. Gwinn, E. Hogberg. A letter from Mrs. F. H. Bird of Seattle, announcing the disappearance of her husband and expressing fear of his physical well being was also read. Mrs. Bird said that she has been unable to get any word from or of her husband since early in September last, when he had just left the employ of Hanover-Bessemer Iron & Copper Co., Fierro, N. Mex., being last seen in Silver City, N. Mex., shortly thereafter. Mr. Bird is a construction engineer usually employed in mill or smelter work, is about 50 years of age, nearly 5 ft. 8 in. tall, of medium build, blue eyes, hair turning somewhat gray, and slightly bald.

Vice-chairman, J. C. Haas, made a brief oral report relative to the work under the double health and war handicap. Then the report of the Secretary-Treasurer was given.

The members named above were then elected officers for the ensuing year. Upon taking the chair, Mr. Haas felicitated the members upon the showing of the past year, notwithstanding the abnormal conditions, and assured those present of his determination to assist in making the coming year the best in the history of Columbia Section.

Mr. O. Lachmund, formerly general manager of B. C. Copper Co., and its successor Canada Copper Corpn., read a paper upon the subject of Tunnel Driving at Copper Mountain, B. C., after which Prof. C. G. Warfel, Asst. Prof. Mining at State College of Washington, gave an oral report upon some electrical smelting experiments in which he had been engaged. This consisted in reducing and refining iron and tungsten and the alloying of these metals. He extended his interesting report

to cover work which he has in contemplation, but this work being in the interest of certain definite engagements it would not be wise or fair to give it publicity at this time. It was promised, however, that a report would be made later through the Columbia Section.

Prof. F. A. Thomson, Dean School of Mines, University of Idaho, led in a discussion on post-bellum problems, touching upon such topics and subjects of direct interest to the mining engineer. Among these were underground industrial improvements, minimizing costs, air service to mining, metallurgy, economics, the gold problem, markets, labor, and wages. Discussion of the above was quite general, Messrs. Ross, Drumheller, Thomson, Linney, Marsh, Eby, Greenough, Warfel, Lachmund, Howard, Porter, Norman, the Chairman, the Secretary, and others engaging therein.

Sidney Norman told of the work L. W. Hutton is doing in the interest of orphans and Prof. Thomson reviewed the contribution for scholarships which Mr. Jerome J. Day has made to encourage the young men of Idaho to matriculate at the School of Mines, University of Idaho. A committee was appointed by the chairman to draft suitable resolutions upon the work Messrs. Hutton and Day are doing, copies to be sent to each and additional copies to be placed on permanent record in Columbia Section and other copies to be sent to the Institute headquarters in New York City. The Members of the committee are Sidney Norman, Prof. F. A. Thomson, and the Secretary.

Prof. L. O. Howard, Dean School of Mines, State College of Washington, very briefly reviewed some research work in the metallurgy of magnesium and stated that he hoped to be able to report some interesting results at some future time.

L. K. ARMSTRONG, *Secretary.*

The Hutton Settlement*

The new Hutton Orphan Settlement, in the Spokane valley, 10 miles east of the city, is the most beautifully conceived and most generously executed charity in the entire history of the Northwest and will rank with any of the kind in the world. Many years ago Mr. L. W. Hutton, who is well known to you as an owner in the great Hercules mine, began to take an interest in the orphans of this section and it was through his generosity that the Spokane Children's Home, at Euclid and Hemlock streets, was cleared of a troublesome mortgage that had limited its capacity for good.

Some idea of the princely nature of Mr. Hutton's gift may be gathered from the fact that the investment per child will be greater than in any similar institution in the United States, and doubtless, therefore, in the world. Every modern improvement and comfort suggested by the best architectural skill and sanitary science has been incorporated in the magnificent pile of buildings. Everything is of absolute fireproof construction. There will be no nightmares of disaster to disturb a beautiful dream come true.

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*Abstract of an address by Sidney Norman at the Annual Meeting of Columbia Section, Dec. 23, 1918.

Mr. Hutton has insisted upon removal of all suggestions of charity as far as humanly possible. The foundation, or settlement as he prefers to call it, is not even finally named and there are no commemorative tablets to remind the children of the debt they will owe for all time. In an effort to make the project at least partially self-supporting, the 200-acre tract has been put under cultivation in expert hands and already generous yield is forthcoming. It is hoped that in years to come the return from a model farm will bring in handsome revenue, besides providing the home with all necessary fruit, vegetables, and wheat. Irrigation laterals, motor trucks, tractors, threshing machine and all the most modern small machinery have already been supplied and it is not improbable that with all the initial expense met, the project will become self-supporting.

The main group of buildings consists of the administration building and four cottage homes, built around an irregular quadrangle which will be the playground for the children. A little farther to the north a modern and commodious laundry and storehouse is to be built, while the space in front, between the main group and the Spokane river, will be dotted with modern barn and other farm houses. Each building is heated from an individual hot water plant, all being connected to a mile-long sewer of 8-in. clay pipe leading to the river. Electricity for power and lighting purposes will be supplied by the Washington Water Power Co. Water supply will be derived from a 125-ft. well, brick-lined and reinforced with concrete, from which a motor-driven pump, set in a chamber near the bottom, will force the supply to a concrete reservoir on an eminence behind the main group of buildings, thus insuring ample head for all domestic and fire purposes. The farm lands have already been supplied with laterals from the main irrigation system of the Spokane valley.

While I have no reliable information as to cost of the Hutton settlement, I am quite sure it will run over $250,000 and should not be surprised if it went to $500,000. The upkeep will amount to an annual income of impressive proportions and it is possible that a heavy endowment will be necessary to keep it running. To my mind, however, the expense is a secondary matter, even to Mr. Hutton. The great outstanding fact is this: that a member of this Section and one who has met with fortune is among the few men big enough and fortunate enough to turn his wealth into the channel of true happiness.

AFFILIATED STUDENT SOCIETIES

ASSOCIATED MINERS, UNIVERSITY OF IDAHO

The following officers of the Associated Miners of the University of Idaho have been elected for the academic year for 1918–1919: President, Lloyd A. McDougal; vice-president, Russel D. Bowers; secretary-treasurer, Charles M. Otter. While the society has been somewhat quiescent during the existence of the S. A. T. C., we are now looking forward to an active session with the resumption of normal university life.

CHARLES M. OTTER, *Sec'y-Treas.*

WOMAN'S AUXILIARY

FOREIGN WAR RELIEF COMMITTEE

Chairman, MRS. JESSE SCOBEY

The task of the committee since Oct. 17, 1918, has been to stimulate and foster interest in the work of the Dispensary in France, to aid and further the work, and to that end has centered on the inauguration of an "Engineers'" day, once a week, at the headquarters of the American Fund for French Wounded, where members of the Auxiliary might join in sewing for this "Dispensary of the New York Section of the Woman's Auxiliary to the A. I. M. E.," recently established at Briey, France.

Letters and pledge forms asking for workers were sent to all members of the Auxiliary in New York City and vicinity, and a most gratifying response has assured the success of the undertaking. The meetings in December, pending the completion of better working facilities at Fund headquarters, were held at the home of Miss Madeline P. Stone, to whom the committee extends its grateful thanks for her hospitality.

A large, well-equipped room at Fund headquarters has now been assigned to the committee for Tuesday of each week, from 10 a. m. to 5 p. m., with Mrs. Percy E. Barbour of the committee as director of work room. All members of the Auxiliary and others whose interests are with the mining profession will be welcome on "Engineers'" day—Tuesdays—at 73 Park Ave.

The finances of the committee are in excellent condition. The general working fund has a balance on hand of $203.64, while $1689.21 remain in the treasury to the credit of the Dispensary fund. This sum will shortly be turned over to the American Fund for French Wounded to be used in broadening the work of the Dispensary at Briey, or to begin new work, according to advices expected from France in the next few weeks.

DIED IN SERVICE

Bailey, Lewis Newton, Master Engineer, Senior Grade, 4th Regiment, U. S. Engineers, Headquarters Company, died of pneumonia at Camp Merritt, N. J., on Apr. 30, 1918.

Baird, Louis, Lieut., Royal Field Artillery, British Army, died on the battlefield in 1915.

Ballamy, John H., Capt., 103d Engineers, killed in action near Fismes, Aug. 9, 1918.

Bowles, Martin F., 2d Lieut., Co. B, 355th Infantry, killed in action, Sept. 3, 1918.

Burt, Andrew, died in active service, 1916.

Cobeldick, William Morley, Royal Engineers, died from gas poisoning on Oct. 7, 1915.

Dougall, Ralph, 4th University Co., Princess Patricia Regiment, killed in action early in the war.

Evans, Alfred Winter, Lieut.-Col., New Zealand Rifle Brigade, D. S. O., D. C. M., killed in action on Oct. 12, 1917.

Gordy, Sheppard B., died in service, Oct. 9, 1918.

Gorman, Thomas C., Lieut., Canadian Engineers, killed in France, Mar. 18, 1918.

Hague, William, 1st Lieut., Engineer Officers' Reserve Corps, died in active service, Jan. 1, 1918.

Hall, William T., Capt., Royal Flying Corps, killed in action, May 19, 1917.

Harbach, Herbert Moore, died of pneumonia, Dec. 6, 1918, at Camp Meade, Md.

Heine, Bernhardt E., Lieut., Aviation Service, died from accident at Fort Sill, Okla., Aug. 10, 1918.

Irving, John Duer, Capt., 11th Engineers, A. E. F., died July 26, 1918, while on active service in France.

Ohnsorg, Norman Lloyd, died of pneumonia, Oct. 11, 1918.

Perry, Edward H., 1st Lieut., Co. D, 6th Regiment Engineers, U. S. Expeditionary Forces, France, killed in action on March 30, 1918.

Pretyman, Frank Remington, 2d Lieut., Royal Engineers, killed in action on June 17, 1916.

Reece, Fred. B., Capt., Royal Engineers, B. E. F., 232d Army Troops Co., killed in action.

Ringlund, Soren, Medical Department, Fort Logan, Colo., died suddenly in camp on July 24, 1918.

Roper, George, Jr., Lieut., Royal Flying Corps, killed in aeroplane accident in England on May 25, 1918.

Smyth, Raymond Weir, died of influenza at the Navy Yard Hospital, League Island, Philadelphia, Sept. 27, 1918.

IN MEMORIAM

SERGEANT HERBERT MOORE HARBACH

SERGEANT HERBERT MOORE HARBACH.

Herbert Moore Harbach was born in Lebanon, Pa., Apr. 4, 1891, graduated from the Lebanon High School in 1911, and entered State College, from which he received his degree of Bachelor of Science in Metallurgical Engineering in 1915. He was employed by the Lackawanna Iron Co., at Buffalo, N. Y., and was later transferred to their Lebanon plant to start up the newly erected benzol plant. He was later made foreman of the coke ovens, which position he held after it was bought by the Bethlehem Steel Co., and until he enlisted in the service of his country in September, 1917. He was stationed at Camp Meade, Md., until the spring of 1918, when he was transferred to the C. W. S., at Niagara Falls, as an expert chemist. There he was engaged in perfecting the various kinds of gases,

and while thus employed was gassed several times, which so affected his heart and lungs that he was unable to withstand an attack of the influenza which developed into pneumonia, from which he died at the end of 24 hours.

He was a member of St. Luke's Episcopal Church, Lebanon, and belonged to the Ancient Accepted Scottish Rite of Freemasonry, Lebanon Lodge 121, I. O. O. F. and Camp 65, P. O. S. of A.

LIEUTENANT NORMAN LLOYD OHNSORG

First Lieutenant Norman Lloyd Ohnsorg died in Nashville, Tenn., on Oct. 11, 1918. He was born in St. Louis, Mo., Jan 10, 1889, and lived in that city until he was 11 years of age when his parents removed to Iron Mountain, Mo., where he spent the next 6 years. On Jan. 10, 1906, he entered the Missouri School of Mines and Metallurgy at Rolla, Mo., and graduated from that institution in 1910, receiving both the Bachelor of Science in Mining Engineering and the Engineer of Mines degrees. In 1912, he received the degree of Bachelor of Science in Metallurgy, and in 1916, the degree of Metallurgical Engineer. After leaving college he was connected with the following companies: Noble Electric Steel Works, Heroult, Shasta Co., Cal.; Mammoth Copper Mining Co., Kennett, Cal.; St. Joseph Lead Co., Herculaneum, Mo.; Granby Smelting & Mining Co., Neodesha, Kans.; The Phosphate Mining Co., Nichols, Fla. While with the last company, he volunteered, in April, 1917, for service in the engineering corps of the U. S. Army. He passed an excellent examination, was accepted and called to Washington and placed in Division T. of the Ordnance Department where he was engaged in research work pertaining to nitrogen. He was then ordered to Sheffield, Ala., where he was second in command of the construction of the Government nitrogen plants at Muscle Shoals. After the completion of the plants, he was ordered to Buffalo, N. Y., on Sept. 28, 1918, to inspect and report on a government plant. After completing this work, he was called back to Sheffield. He left Buffalo on Oct. 6, but delayed trains caused him to miss connections in Cincinnati where he had to wait 12 hours. He had not been feeling well for several days before leaving Buffalo; influenza developed, and when his train reached Nashville, Tenn., he was too ill to continue his journey and was taken to the Kissam Hall Hospital, Vanderbilt University, where he died of pneumonia.

LIEUT. NORMAN LLOYD OHNSORG.

He was a young man of unusual ability and high moral character, always bright, happy and kind, faithful and honorable in all things; loved by both his associates and those under his authority. His life and character cannot be better described than by the following quotation from one of his superior officers: "Lieutenant Ohnsorg was a man loved

by all of us, always cheerful, just and kind, with unusual executive ability. We can never expect to find a man who has his ability and fine temperament and his position can never be filled as he filled it."

He was happily married and leaves to mourn his loss a wife, Constance E. (Rogers) Ohnsorg and a baby girl born since his death, Nov. 29, 1918, a father, W. H. Ohnsorg, mother, Ida May Ohnsorg, and a sister, Mrs. Stuart Strathy McNair.

He was a member of the American Institute of Mining Engineers and of the Florida Phosphate Miners' Association.

HARVARD SCHOOL OF ENGINEERING

On Jan. 1, Harvard opened its reorganized School of Engineering and will continue the work during the summer to enable the entrants to complete a full year's work by the opening of the next academic year in September. Some time ago Harvard University and the Massachusetts Institute of Technology agreed to combine effort in engineering instruction, making use of funds provided under the will of the late Gordon McKay. The agreement was objected to and the Massachusetts Supreme Court held that the arrangement was not in accord with the provisions of the will. The new arrangement has been approved both by the trustees of the McKay estate and by the governing boards of the university. Instruction will be offered in the following subjects; mechanical engineering, civil engineering, sanitary engineering, electrical engineering, mining and metallurgy, and industrial chemistry. Henry Lloyd Smyth has been appointed professor of mining and metallurgy, Albert Sauveur, professor of metallurgy and metallography, and Louis C. Graton, professor of economic geology.

NATIONAL WORKING CONDITIONS

Anticipating the increasing importance of establishing working conditions on a scientific basis, the Department of Labor created the Working Conditions Service. This service is distinct from that performed by the Mediation and Conciliation branch, which deals with working conditions and industrial relations as controversial issues between employers and employees. The work of the Service is conducted through three coördinated divisions; Division of Industrial Hygiene and Medicine, Division of Labor Administration, and Division of Safety Engineering.

The Division of Industrial Hygiene and Medicine will develop standards of sanitation and medical practice in industries. The personnel of this Division is detailed from the United States Public Health Service.

The Division of Labor Administration will advise employers as to employment systems and labor management policies, and assist in putting into operation standard policies.

The Division of Safety Engineering will develop standards and practices for accident prevention, and advise employers as to safety methods best adapted to their plants.

The demand upon the newly established Working Conditions Service for industrial physicians and surgeons has grown so rapidly that there has been established a bureau of registry of physicians specially skilled in this growing phase of medical and surgical specialization.

EMPLOYMENT SERVICE FOR DISCHARGED OFFICERS AND MILITARY MEN

A professional and special section of the United States Employment Service, Department of Labor, has been created for the purpose of aiding officers and men who have been discharged from military service, but who, for various reasons, cannot resume their former positions, to place themselves in industry without loss of time. Its work is carried out in conjunction with the Engineering Societies Employment Bureau. The machinery of this new professional section is being set up as rapidly as possible, and an office is already in operation at 16 East 42d St., New York. The work in the New York State district is under the direction of Mr. Henry Bruere, formerly City Chamberlain of New York City. Dr. Thomas T. Read, Chairman of the A. I. M. E. Committee on Industrial Organization, has charge of the clearance between the State offices of the Eastern States. This service is designed for the purpose of placing not only men in the engineering professions, but for all other kinds of professional and highly trained, skilled men. Full details regarding the qualifications desired in a man should be given, so that employers may be put in touch only with such available men as will fully qualify for the positions.

COÖPERATION OF AMERICAN, BRITISH, AND FRENCH SCHOOLS

Last November, when the British Educational Mission was visiting this country, letters were sent to the various mining schools asking what arrangements had been made for coöperating with British and French schools. Of the eleven schools from which replies were received, none had taken any definite steps in this direction. The Colorado School of Mines, though, stated that it was offering scholarships to all men who had served in the U. S. Army and Navy during the war. A letter was also sent to Sir Henry Miers, Vice-chancellor of the University of Manchester, who was the head of the British Mission. He replied as follows:

"In my opinion the mining profession is second to none in the responsibility of the duties which it involves or to which it leads in all parts of the world; also it is a profession in which the student or teacher has much to gain by migrating to foreign countries. This applies in a special degree to British students coming to America where they will be able to enlarge their views by a widened experience. We (the Mission) have everywhere found the most cordial acceptance of such proposals. Several of the British Universities have recently instituted a new doctorate of philosophy attainable after 2 or 3 years course of advanced study; this scheme includes Oxford and Manchester. The conditions admitting to the degree course are that the applicant should be a graduate of an approved University and should show evidence that he is qualified to pursue the course which he proposes."

In a conversation with Prof. Alfred C. Lane, of Tufts College, Sir Henry Miers said that students from Great Britain should be most easily attracted to America, both to universities and colleges and technological institutions. He doubts, however, whether Great Britain can offer America, in this respect, as much as America can offer her. Prof. Lane, though, is quite sure that, especially for geologists, there is much to be

gained by seeing the typical regions and sections where geology was first studied.

The War Department has made arrangements by which members of the American Expeditionary Force may enter French schools of all grades.

BABBITT COMPOSITIONS RECOMMENDED BY BEARING METALS MANUFACTURERS

Last October a committee was appointed by The War Service Association of Manufacturers of Solder and Bearing Metals, Inc. to consider the report of the U. S. Bureau of Standards to the Conservation Division of the War Industries Board, a letter of the War Industries Board, and the discussions of this letter as reported at the meetings of association and to summarize the information thus obtained. The report of this committee has just been printed.

The committee agrees with the Bureau of Standards that 99 per cent. tin can be used. It also finds that a very small amount of lead might increase the tendency of the bearing to crack and that lead has a hardening effect on babbitts up to a possible limit of 10 per cent. of lead. Still in the so-called genuine babbitts, in the presence of lead a certain proportion of low melting point eutectic is introduced which admits of the bearing being poured into thinner sections and is decidedly advantageous in the die-casting process in producing a much smoother casting. But the committee recommends that the Bureau of Standards thoroughly investigate this point. Lead-base babbitts, to give satisfactory service, must be carefully made of the proper raw materials. The bronze bearing that has been thoroughly tinned and containing the thinnest possible babbitt lining is now becoming recognized as the ideal bearing. The compositions recommended by the committee are as follows:

Babbitt Compositions Recommended

Alloy, Grade No.	Tin, Per Cent.	Antimony, Per Cent.	Lead, Per Cent.	Copper, Per Cent.	Iron, Max., Per Cent.	Arsenic, Max., Per Cent.	Zinc	Aluminum
1......	91	4½	1	4½	0.08	0.10	None	None
2......	89	7½	1	3½	0.08	0.10	None	None
3......	83⅓	8⅓	1	8⅓	0.08	0.10	None	None
4......	75	12	10	3	0.08	0.15	None	None
5......	65	15	18	2	0.08	0.15	None	None
6......	61½	10½	25	3	0.08	0.15	None	None
7......	45	7½	46	1½	0.08	0.15	None	None
8......	30½	8½	60	1	0.08	0.15	None	None
9......	20	15	63½	1½	0.08	0.15	None	None
10......	10	15	75	0.50*a*		0.20	None	None
11......	5	15	80	0.50*a*		0.20	None	None
12......	5	10	85	0.50*a*		0.20	None	None
13......	2	15	83	0.50*a*		0.20	None	None
14......		15	85	0.50*a*		1.00	None	None
15......		10	90	0.50*a*		1.00	None	None
16......			98*b*				None	None
17......			98*c*				None	None

a, Maximum. *b*, Approximate, balance alkali metals.
c, Approximate, balance alkaline earth metals.

The most desirable alloys on the list of lowest tin content for the following requirements are:

A. For resistance to extreme pressures and impacts, when the design of the bearing is such that a heavy liner is used, alloy No. 3.

B. For supporting smaller loads, or resisting smaller impacts, and when thinner linings are used, alloy No. 2.

C. For the thinnest liners, particularly those attached to bronze or steel backs by the soldering process, and under conditions where the shocks are not so severe as to require the use of harder alloys, either alloy No. 6, 7, or 8, depending on which exhibits the best physical properties (these to be determined by the Bureau of Standards).

D. For all classes of service other than A, B, C, E, or F, alloy No. 10, which is the most satisfactory lead-base babbitt containing tin and antimony.

E. For service under low pressures, and without impact, operated at fairly low speeds, alloy No. 14.

F. Alloys Nos. 16 and 17 for the special classes of service for which they may be found suited after sufficient service experience.

PEACE—NOT THE END BUT THE BEGINNING

In an address delivered at Atlantic City, N. J., Dec. 5, 1918, M. L. Requa, General Director, Oil Division of the United States Fuel Administration, said:

We face a new era with all its uncertainties. We have arrived at the period of reconstruction and are face to face with the problems concerning which we have so often speculated during the past four years. In all this reconstruction work the United States must bear an important part. We are looked upon to lead the way, to blaze the trail and our actions will have a profound influence upon the rest of the world. If we are to succeed, even in part, we must not be ashamed to practise economy; we must not despise the day of small things; the little savings; we must have the closest coöperation between Government and industry.

Just as truly do we need civic awakening. All that we have ever fought for, the liberty of the world, is comprehended in the ballot; and yet how lightly we have held this great privilege! We need, if we are to reap in full the benefits of the past 18 mo., an awakened civic consciousness; a jealous guarding of government; a resolution that we will, each and all, perform to the full the duties imposed upon us by Democracy; that we will perform more completely the obligations resting upon us as citizens.

During the war, industry, through sane coöperation and intelligent effort, has accomplished results possible of attainment in no other way. Government and industry have worked hand in hand and pointed the way to future activities which, if realized, can but be most highly beneficial to all. If Government and industry are to fulfill their respective duties satisfactorily, it is obvious that there should be complete mutual confidence. Industry must not attempt to "put something over"—and Government must treat with industry upon the high plane that has characterized the public utterances of the President during the war. The individual who cannot conform to these high ideals should have no place in industry, and equally no place in Government. If the dignified and broad princi-

ples enunciated by the President can be made the common platform, I am persuaded that honest men make up so large a majority of industry there will be no question but that the dishonest can be driven out or made to conform to the high standards set. The official who looks to the balance-sheet of his company as the only satisfactory answer to his stewardship is shortsighted and has but faint conception of the real nature of his trust. His is a far more important task. In the case of the great corporation he is in truth the trustee for the people, administering affairs that—while perhaps not legally so construed—are as truly public-service corporations as are our railways.

In place of the doctrine of unrestricted competition, we must substitute the doctrine of coöperation. But coöperation must be founded on mutual confidence, free of special privileges, secret understandings, and unfair tactics.

Among necessary reconstruction measures there are three that I consider fundamental and of first importance: We need, of course, a national budget. The budget is the foundation, without which we cannot hope materially to improve our past record of extravagance.

Members of the Cabinet should sit in the House, take part in debate, answer questions, and upon a vote of censure resign. They should, in short, be responsible to Congress for the proper administration of the departments over which they preside.

We should create the United States Board of Trade, under whose jurisdiction should come the industrial and commercial activities of the nation. This body should largely parallel the Supreme Court of the United States in manner of appointment; a seat upon this board should be as eagerly sought and should confer the same high honor, as related to industry, as a seat upon the Supreme Bench confers upon Law.

This board should have supervision of American industry. It would plan all policies of foreign trades relations; it would limit, guide, and counsel, both as to foreign and domestic commerce; it would, in, short, prescribe the ethics, limit the activities, determine the practices, and represent Government—to the end that industry should most efficiently, beneficently, and wisely perform its functions as the servant of the people.

CHANGE OF ADDRESS

To ensure the receipt of the *Bulletin*, all changes of address must be received before the 20th of the preceding month when the mailing lists must be closed.

UNIFORM LISTS OF TECHNICAL SYMBOLS

During February there will be a meeting of the Committee on Technical Nomenclature of the Society for the Promotion of Engineering Education and representatives of the various engineering societies, to do the preliminary work necessary for the adoption of uniform lists of technical symbols. At this time it is expected that lists of symbols in general use throughout the country will be presented and the symbols most generally used will be recommended for adoption.

NEWS FROM MEMBERS IN SERVICE

Lieut. Maxwell E. Erdory, now with the Army of Occupation in France, writes as follows:

"The 602d Engrs., many of whose officers are members of the Institute, started its active service in France at Avocourt, where we built a road across 'No Man's Land.' This road from Avocourt to Montfaucon started us on a career of road building which lasted from Sept. 26 to Nov. 9. The engineer in war has no working hours. Our first job meant 50 hr. continuous work, a layoff of 4 hr. and 18 hr. more. That was our initiation in this war game.

"Back in the States we practised building trenches, dugouts, and underground shelters of all sorts. In France we were unfortunate enough to come upon the scene when the so-called open warfare started. That made all the above unnecessary. Roads was the cry and our job was to see that all the artillery got their roads and got over them.

"I might mention here that the roads of France, which were in excellent condition except for numerous shell holes, were one of the leading factors in the rapid termination of the war.

"We built a narrow-gage railroad from Romagne to Landre St. George which cost us a few men. At Stenay we did our first bridge building. We built nine bridges across the Meuse, capable of carrying tanks, in 18 hr. The next day the American army crossed these bridges on their way to Virton, Belgium, and the Rhine.

"Our course from Virton, Belgium, took us through Longwy, Musson, and Athus, in which towns I inspected the steel plants. In Musson as well as Longwy the Germans had destroyed most of the blast furnaces. This destruction began in August, 1917. In Athus the furnaces were in good condition, the Germans having removed all motors and electrical apparatus, rendering the plant inoperative. I have taken several photos of interest of these plants.

"It is but fitting that I say that the engineer in this war has contributed much toward its success but the "Doughboy" is its hero and we engineers one and all say "All hail the Doughboy."

Emil Spurny writes that on June 1, 1918, the Presbyterian Hospital Unit, recruited in New York City, arrived at a town on the coast of France, about 15 mi. north of Havre, having taken over the operation, etc., of No. 1 General Hospital, B. E. F. The hospital consists of three buildings, which in peace time are used as summer hotels. They expect to be back in the United States at an early date.

E. Steidle sends the following note: "While attached, with my company, to an attacking unit of Marines, I was unfortunate enough to receive a second injury and this time suffered the loss of my right eye. I was to be shipped home a cripple when my Colonel arrived and matters were arranged so that I could return to my regiment. I am now commanding the First Battalion of the First Gas Regiment (formerly the 30th Engineers). I will not receive my majority for the present, due to the recent G. H. Q. ruling regarding promotions, but I will have the pleasure of taking home one of the best fighting units in the whole American Expeditionary Forces, and of mustering it out. I might add that over half of the battalion are college men and the balance are skilled in some trade and are of an exceptionally high caliber. We expect to entrain for a base port at an early date, which means an early trip home."

Lieut. S. H. Zimmerman writes as follows: "The notification announcing my change of status to a full membership in the Institute arrived at a moment when we were busily engaged with the boche in the Argonne, on the 19th of October. You will no doubt be delighted to hear that the A. I. M. E. was able to accomplish more that day than the boche (even though the latter were resorting to 6-in. shells) in the matter of status changing. While the A. I. M. E. did actually make the change, friend] boche could not do it with his best shells although one did put me 'hors de combat' up to the present time with a small wound."

Lieut. W. Hooker, R. E., writes: "I have just had your letter forwarded to me from England. Referring to your remark as to interesting matter about the experiences met with by the members of the Institute, I almost think I could fill a small volume—given a little leisure, a thing we are much in want of over here for the life has been most strenuous especially during and since our little push of over 350 mi. in 6 to 7 weeks, the capture of over 80,000 prisoners, goodness knows how many dead, and wounded, and over 400 tons—an incredible amount—of war and other material, etc., all of which will be common knowledge to you in the U. S. A. through the medium of the newspapers. Of course there are lots of items of personal experience that are not within the purview of the press and simply relate to experiences reached by the individual, a few of which I will give you in the fewest possible words.

"I am engaged (and have been throughout this year) in railway engineering work such as tunneling, replacing destroyed bridges and track, also laying new track. Although a mining man I have found myself through knowledge of mathematics and the theodolite quite 'au fait' at railway work—so much so that I have been recommended for mention in dispatches for success in some difficult engineering work in connection therewith. I do not consider there is very much merit in doing one's duty, especially in this sort of work, as care in details and the exercise of a good kind of common sense generally carry one through. One of the most interesting works I was engaged in was a light railway from Jerusalem to Birch about 19½ mi. north of the former. It was laid out over a very rough and rocky bit of country of limestone (cretaceous) and was very precipitous. Its chief interest apart from a technical view lay in the historic relics passed and the Biblical association connected with it. A view of Nebi-Samwil (Samuel the Prophet's grave) was conspicuous on the left hand, or west, the tomb being erected on a high hill. A few miles out from Jerusalem the line runs over the tombs of the Judges of Israel, with the Lord Chief Justice's tomb first (a deep double chamber 32 ft. below the surface carved in the solid rock). There are rabbetted doorways to which stones were fitted and then sealed up. These, however, have been removed, Further on are King Solomon's wine presses, on the west side of the track, the stain of the wine being so deep in the stone that it is yet clearly visible. The press is cut in the solid rock and also circular chambers below the ground level wherein it is believed the wine was stored. On the right hand, east, is a stronghold or ancient fort which was occupied by the Syrians for some years; they were ejected by Simon the brother of Judas Maccabaeus. This fort is a most interesting ruin, the major portion being cut out of the solid rock. In one part there is a small wine press in excellent preservation with the mark of the tools (masons') still clear. The walls are very massive, and of the type termed 'monolithic.' The railroad winds

round the steep scarp of an abrupt hill beyond this and has been cut out of the solid like a ledge. Beyond here is Shâfat, a very ancient village overlooked by a steep conical mountain from which on a clear day a wonderful view of the valley of the Jordan, the mountains of Moab, and the Dead Sea is obtained, stretched like a map, 3800 ft. below and about 22 to 23 mi. away. This is a scene of great beauty and picturesqueness. The steep slopes of the mountain and the deep valleys, with the conical tops of distinct hills, the green line indicating the course of the Jordan and the wonderful blue of the Dead Sea, make up with the massive background of the Moabite Hills, over 4000 ft. above the sea level, a view of singular grandeur with a charm all its own. On the southern face the dome of the Mosque of Omar and that of the Holy Sepulchre, together with the many spires and minarets in the distance, proclaim the Holy City itself. In the near foreground is the valley of Jehoshaphat and on the left of that the Mount of Olives and Bethany. Further north we reach Er Ram with several tombs cut in the living rock, the origin of which and by whose remains they were occupied, I have been unable to learn. The terminus of the line is at Ramallah and Birch, both spots of historic interest during the time of the Hebraic domination. There are several ruins scattered about these villages, which no doubt would have repaid closer inspection and research but duty was the watchword and private interest had to be subordinated to public and national needs, therefore, I was unable to get any information thereon. I will endeavor to send you more items of interest when time is available, meantime I close this letter hoping it may be of some interest to both yourself and any member who cares for this sort of archæological matter."

ADDITIONAL LIST OF MEMBERS OF THE INSTITUTE IN MILITARY SERVICE

(The following list contains the names of those members of the Institute of whose connection with military service we have only recently become acquainted.)

BLACKNER, L. A., Capt., Engineers, U. S. A., 217th Engineers (Sapper) Regiment, Camp Beauregard, La.

BURKE, JAMES M., Flying Ensign, Naval Aviation.

HENNIGER, WALDEMAR F., U. S. Army.

JENNINGS, E. B., 2d Lieut., A. S., S. R. C., Aerial Observer.

KERNAN, THOMAS H., U. S. Army.

LINTNER, E. J., 2d Lieut., Coast Artillery.

MAZANY, M. S., Lieut., 214th Engineers, Camp Custer, Mich.

REBER, W. H., Warrant Machinist, U. S. Navy Steam Engineers' School, Hoboken, N. J.

VIVIAN, GEORGE F., 2d Lieut, 212th Engineers, Camp Devens, Mass.

WARNER, ROBERT K., Corporal, 301st Engineers, 78th Div., Army of Occupation, France.

WOOD, JAMES T., JR., 2d Regiment, 1st Brigade, Field Artillery Replacement Draft, Camp Jackson, S. C.

YEWELL, P. R., Corporal, U. S. Army.

PERSONAL

The following is an incomplete list of members and guests who called at Institute headquarters during the period Dec. 10, 1918 to Jan. 10, 1919.

P. G. **Bandy**, Mexico City.
Bennett R. **Bates**, Berkeley, Cal.
William T. **Bates**, Mascot, Tenn.
Lt. Don C. **Billick**, Alturas, Cal.
L. E. **Booth**, Watertown, Mass.
J. T. **Boyd**, Denver, Colo.
J. R. **Buchanan**, Pasadena, Cal.
Ensign G. M. **Burke**.
Captain E. H. **Clausen**.
F. L. **Cole**, Manila, P. I.
Joules **Cousin**.
A. Faison **Dixon**, Washington, D. C.
James T. **Dixon**, London, England.
Everett **Drennen**, Elkins, W. Va.
F. **Eichelberger**, Helena, Mont.
R. B. **Eldredge**, Colorado Springs, Colo.
W. F. **Ferrier**, Ottawa.
Martin **Fishback**, Benson, Ariz.
T. E. **Fisher**, Dover, N. J.
D. C. **Gilbert**, Ft. Wayne, Ind.
Lt. Lauriston B. **Herr**, Cuba.
G. S. **Holmquist**, Washington, D. C.
Lt. E. Ross **Housholder**, Ohio.
Hugh C. **Ingle**, Santa Rosa, Cal.
Lt. M. W. **Kishman**, Ariz.
Hugo E. **Koch**, Watertown, Mass.
H. M. **LaFollette**, LaFollette, Tenn.
Clinton R. **Lewis**, Dawson, Y. T.
Wm. B. **McKinley**, Yonkers, N. Y.
Captain C. E. **McQuigg**, Conn.
Lt. H. G. **Mathews**, Cal.
Lt. M. S. **Mazany**, Mich.
Ralph A. **Meyer**, Hill City, S. D.
C. F. **Moore**, Boston, Mass.
H. W. **Nichols**, Chicago, Ill.
R. B. **Olsen**, Mays Landing, N. J.
M. L. **O'Neale**, Gouverneur, N. Y.
F. W. **Osborn**, New York, N. Y.
Lt. Fred S. **Porter**, Alaska.
G. M. **Richards**, Palmerton, Pa.
T. C. **Roberts**, E. Orange, N. J.
W. E. **Ruder**, Schenectady, N. Y.
Ensign W. A. **RuKeyser**, Boston.
A. H. **Sawyer**, Boston, Mass.
Lt. D. F. **Schindler**, New York.
L. G. **Sparks**, Greensburg, Kan.
W. H. **Staver**, New York, N. Y.
Douglas B. **Sterrett**, St. Cyr, Canada.
Warren D. **Thompson**.
Enrique **Touceda**, Albany, N. Y.
Mathew **van Siclen**.
Flying Cadet Christian **Vrang**, Cal.
L. G. **Weeks**, Bisbee, Ariz.
C. E. **Wheelock**, Mogollon, N. M.
Major A. E. **White**, Washington, D. C.
Lt. J. L. **White**, Humboldt, Ariz.

The Secretary of the Institute has received with sincere appreciation a Christmas card extending the season's greetings from the officers' mess of the 3d Tunnelling Company, Canadian Engineers, B. E. F., France, and takes this means of reciprocating to these officers and men of the company the best wishes of the members of the Board of Directors.

Charles E. Addams has removed from Ray, Ariz., to Phoenix, Ariz., where he is chairman and director of the Arizona State Council of Defense.

Paul S. Anderson of Baker, Oregon, has accepted the position of superintendent of the Falls Creek Mining Co., at Granite, Idaho.

George S. Backus, formerly at Telluride, Colo., is now with the Minerals Separation North American Corporation at 220 Battery St., San Francisco, Cal.

Bennett R. Bates is manager with the Mineral Hill Consolidated Copper Co., at Tucson, Ariz.

Alfred C. Callen, at the request of the Federal Board for Vocational Education, is visiting the important mining districts of the United States and will outline plans and methods for carrying secondary mining education to the miners, both coal and metal.

G. H. Clevenger has changed his address from Colorado Springs, Colo., to 1023 Sixteenth St., Washington, D. C., offices of the National Research Council, where he has assumed the position of Chairman of the Section on Metallurgy.

B. L. Cunningham, lately of Berkeley, Cal., is at present consulting geologist for the Doheney Pacific Petroleum Co., at 1011 Security Building, Los Angeles, Cal.

E. W. Davis is Superintendent of the School of Mines Experiment Station of the University of Minnesota.

Waldemar F. Dietrich has accepted the position of assistant professor of mining at Stanford University, Cal.

Lucian Eaton, for the past seven months a captain of engineers in the U. S. Army, was discharged on Dec. 16. He is returning to his former position, Superintendent, Ishpeming District, Cleveland-Cliffs Iron Co., Ishpeming, Mich.

William H. Finkeldey, metallographer, is connected with the New Jersey Zinc Co., at the Palmerton, Pa., plant.

D. M. Folsom is manager of the statistical department of the General Petroleum Corpn., with offices in the Alaska Commercial Bldg., San Francisco, Cal.

George W. Fry is general manager at the Commonwealth Public Service Co.'s offices in the Merchants National Bank Bldg., Fort Smith, Ark.

Donald C. Gilbert, second lieutenant, engineers, U. S. A., having received an honorable discharge, has accepted a position with the Kennecott Copper Corpn. at Kennecott, Alaska.

G. E. Harrison has resigned his position with Corrigan, McKinney & Co. of Hibbing, Minn., and is now in Crystal Falls, Mich., as district superintendent for the McKinney Steel Co., in charge of their Menominee Range operations.

Waldemar F. Henniger has recently been mustered out of the army and has resumed his position as petroleum geologist with the Gulf Production Co. His address is 1210 Vine St., Brownwood, Tex.

Nathaniel Herz, having received his discharge from military service, is now at 45 Sheldon Terrace, New Haven, Conn.

J. N. Houser is vice-president and general manager of the American Zinc, Lead & Smelting Co. of Mascot, Tenn.

John A. Jess is a member of the staff of the Forest Products Laboratory at Madison, Wis.

Ralph N. Marble, Jr., having been placed on inactive duty, has accepted a position with the Mahoning Ore & Steel Co. at Hibbing, Minn.

A. J. Miller's new address is Care of Stimpson Equipment Co., 318 Felt Bldg., Salt Lake City, Utah.

W. D. B. Motter, Jr., has resigned as manager of the Benson Mines Co. to join the staff of Guggenheim Brothers as assistant consulting mining engineer, and after a 3 months' trip to South America will be at 120 Broadway, New York City.

Burton B. Nieding's address is United Verde Extension Co., Jerome, Ariz.

Alfred C. North, having been granted a vacation from his duties as engineer for the Eden Mining Co., a subsidiary of the Tonopah Mining Co., of Nevada, operating in the Pis Pis mining district, is on his way to the United States.

M. L. O'Neale has resigned as superintendent of the Connellsville Basin Coke Co., Morgantown, W. Va., to accept the position of mine and mill superintendent of the New York Pyrites Co., at Gouverneur, N. Y.

James M. Platt has accepted a position with the Cia Min. La Blanca y Anexas at Pachuca, Hgo., Mexico.

Fred S. Porter is at present with the Kennecott Copper Corpn., Staff House, Kennecott, Alaska, having recently received an honorable discharge from the army.

Charles H. Reed, formerly of Denver, Colo., is now with the Primos Exploration Co. at the Urad mine, Empire, Colo.

J. K. Roberts, having been released from the U. S. Navy, has resumed his former duties as instructor in geology at Emory and Henry College, Emory, Va.

C. Carleton Semple has taken a position with the Peruvian Copper & Smelting Co. at Juaja, Peru.

Bert F. Smith has resigned his position as field engineer with the American Smelting & Refining Co. of Spokane, Wash., and is now with the Creede Exploration Co. at Creede, Colo.

Marshall G. Spencer has resigned as assistant superintendent of foundry at the Watertown Arsenal, Watertown, Mass., and accepted a position with the Electric Steel Co. of Indiana, Box 327, Indianapolis, Ind.

Arthur L. Sweetser has accepted the position of mining and chemical engineer with the Penyon Syndicate at Antofagasta, Chile.

J. R. Thoenen, on Dec. 1, resigned as superintendent of the Garson mine for the Mond Nickel Co., Ltd., of Canada to accept the position of superintendent of mines for the Indiana Fluorspar & Lead Co. at Elizabethtown, Ill.

Walter H. Triplett has received an honorable discharge from the service. His present address is 5727 Colorado Ave., Washington, D. C.

A. A. Turner, lately at Barstow, Cal., is now with the Britannia Mining Co. at Cuba 71, Havana, Cuba.

S. Power Warren is mill superintendent with the Colorado Centra Mines Co. at Georgetown, Colo.

I. Edmund Waechter has accepted a position with the Carnegie Steel Co. at the Youngstown, Ohio, plant.

L. G. Weeks, recently C. Q. M. (A), U. S. Navy, has resumed his duties as a mining geologist at Chilton, Wis.

W. H. Wellman has removed from Esqueda, Son., Mex., to Valedon, New Mexico, where he is superintendent of concentration with the 85 Mining Co.

Joseph L. White, Engineers, U. S. A., upon returning to civil life has accepted the position of field engineer with the Consolidated Arizona Smelting Co. at Humboldt, Ariz.

ENGINEERS AVAILABLE

(Under this heading will be published notes sent to the Secretary of the Institute by members or other persons introduced by members.)

No. 528.—Mechanical engineer, member and technical graduate, with broad experience in shopwork, the economical handling and processing of materials and in plant design construction and maintenance and with good experience in mechanical engineering problems, as occurring at mines, available about Feb. 1 for a connection having sufficient work of this

nature, as compared with mining engineering, to justify the attention of a high-grade man. $250.

No. 529.—Member, age 32, mining engineer, recently discharged Lieutenant of Heavy Artillery, now available. Ten years' experience, gold-silver and copper mining and milling, construction, teaching and valuation. Prefer work on mine examination, or as superintendent.

No. 530.—Member, age 24, single, graduate Missouri School of Mines, two summers mining experience, speaks Spanish. At present available having just received a discharge from military service.

No. 531.—Mining engineer, member, technical graduate, married, age 30, desires position as superintendent or engineer. Has had 9 years' experience as miner, millman, surveyor and superintendent. Just released from service. Best of references.

No. 532.—Mine manager or superintendent. Graduate mining engineer with 10 years' experience as manager and operator of mines. First class references. At present an officer in U. S. Army, but expects discharge on or before Feb. 1.

No. 533.—Member, mining engineer and geologist, technical graduate, age 28, single, experienced mining engineering and geology in United States, desires to get located in West as mining geologist or mining engineer and geologist combined. Besides engineering, can do geologic survey, exploring, developing and micro-petrographic research. Can give best references. Hard worker and reliable. Available Feb. 1.

No. 534.—Junior member, age 25, single, technical graduate, experienced in smelting of manganese ores in the electric furnace, desires position in electric smelter. Has also had some experience in the manufacture of carbon electrodes.

No. 535.—Member, mining engineer, technical graduate, age 34 years, experience as engineer for coal companies. Three and one-half years with one company and 5 years with another. Have good recommendations. Recently honorably discharged, First Lieutenant, U. S. Army. Desires position, preferably in West. Salary last received $175 per month.

No. 536.—Member, graduate mining engineer and geologist, married, age 30 years. Eight years' experience in coal and metal mines as engineer, geologist and superintendent. At present engaged on geologic survey. Desires change to company offering greater chance for advancement. Available upon short notice.

No. 537.—Member, technical graduate with 20 years' experience in United States, Mexico and Russia as superintendent, manager and consulting engineer for large interests. Experienced in examination, development and operation of large properties. Owing to conditions in Russia, seeks other connections. Speaks Spanish and can handle native labor.

No. 538.—Engineer, member, technical education, wide experience in all branches of metal mining, organization and management. Exceptional experience exploration. During past year in charge of large operation in connection with war industries. Thorough Spanish. References all previous employers. Available February. Correspondence and personal interview solicited.

No. 539.—Mining engineer, age 33, just discharged from corps of Engineers, U. S. Army, desires position in East on mining staff of company operating mines in U. S. or South America to work on exploration,

development or improvements. Twelve years' experience in such work in the West and Latin America. Speaks Spanish fluently.

No. 540.—Member, age 30, married, technical, 7 years' experience copper and iron mines as transitman, mine sampling, millman and efficiency engineer. Desires position of superintendent or assistant superintendent or efficiency engineer. Recently released from aviation. Will go to any healthy place. Minimum salary $250.

No. 541.—Mining engineer, member, graduate of Columbia School of Mines, married, age 38, desires position as superintendent, assistant superintendent or engineer. Has had 15 years' experience in mining, surveying and engineering in the Southwest. Will consider no position not offering a future. Available at once.

No. 542.—Mining engineer of many years' experience both in executive and subordinate capacity, having heretofore retired with sufficient competence, wishes employment with first class mining company where his experience will be of value. The question of remuneration is of secondary importance.

No. 543.—Member, age 39, married, technical training, 18 years' all-round experience in gold-silver mining and milling in Mexico and the States, including responsibility of mine development, mill construction, operation and management. Have held interest in property enough to know the value of a dollar from the owner's standpoint and can get results. Available after Feb. 1.

No. 544.—Mining or mechanical engineer with an extensive technical education covering mining, mechanical and metallurgical engineering, with a supplementary legal education and about 10 years' varied practical experience, who is familiar with the design, construction, operation and maintenance of power, mining, chemical, metallurgical and cement plants, and who has handled men in large numbers and work of considerable magnitude, is open for engagement.

POSITIONS VACANT

No. 364.—Asbestos mine in Canada desires assistant mine superintendent to supervise mining of ore and delivery of same to mill bins. To be successful, applicant should be good organizer and able to get production at right cost; one with experience on steam-shovel rock work preferred. Knowledge of French desirable. Salary $175–$200 per month; permanent position; chance for advancement. Company-owned houses available at nominal rental.

No. 365.—Research metallographist. Man of commercial experience in alloy steels for position offering opportunity for constructive work over wide range of alloys, with large concern providing ample working facilities. In replying please give full details of training, experience, age and salary desired.

No. 366.—Engineer to do surveying and making of mine maps covering inside development of mine as well as property outside of the mines. Matter of salary depends on man's experience and efficiency.

No. 367.—Engineer, preferably single man to be detailed mostly on mine surveying. Salary to start $130 per month and expenses while on the road.

No. 368.—Competent road engineer having sufficient capacity and organization ability to take responsible charge of work. Entire control of work is in hands of county court of three members. County has recently been bonded to the amount of $1,000,000 to be used in road construction.

No. 369.—Thoroughly competent mining engineer of known ability who will also be mining superintendent for large property located in Oregon. Salary commensurate with experience.

No. 370.—Young mining engineer, recent graduate, for mine in Chile. Contract for three years. Salary $120 per month with transportation.

No. 371.—Instructor wanted in ore-dressing and metallurgy for technical school in the Middle West. Practical experience required and some teaching experience desirable. Salary $1500 per annum. Work to begin as near Feb. 1, as possible.

No. 372. Wanted.—Cyanide shift boss for position in Ecuador. Transportation from and to New York with a two-year contract. Salary $150 with board and lodging, to begin on starting work.

FORTHCOMING MEETINGS OF SOCIETIES

Organization	Place	Date
		1919
Automotive Engineers	New York, N. Y.	Feb. 4–6
American Institute of Mining Engineers	**New York, N. Y.**	**Feb. 17–20**
New England Association of Gas Engineers	**Boston, Mass.**	**Feb. 19**
American Institute of Electrical Engineers	New York, N. Y.	Feb. 19–21
National Society for the Study of Education	Chicago, Ill.	Feb. 25–28
American Railway Engineering Association	**Chicago, Ill.**	**Mch. 18–20**
American Electrochemical Society	New York, N. Y.	Apr. 3–5

BIOGRAPHICAL NOTICES

CHARLES P. BROOKS

Charles P. Brooks, who had been identified with the mining industry in the West since 1874, having served at various times as mining and consulting engineer for most of the largest mining properties in Utah, died Dec. 11, at his home in Salt Lake City, of heart failure, after an illness of about one month. He was a very close business friend of the late Thomas Kearns and David Keith. In recent years he had been closely identified with the Silver King Coalition Mining Co., the Chief Consolidated Mining Co., the Grand Central Mining Co., the Prince Consolidated Mining & Smelting Co., and many other large properties.

Mr. Brooks was born in Washingtonville, Orange County, New York, Aug. 21, 1851; he was the son of Charles Edward Brooks and Adeline Cannon Brooks. When 14 years of age he attended school at Chester, N. J., for one term, and accompanied the assistant principal of Chester Academy to New Paltz, N. Y., and finished the school year there. In 1866 he entered Dr. Stiles's school at Deckertown, N. J., and later the Sheffield School at Yale in 1867, where he received the degree of civil engineer with the class of 1870.

He was married, at Salt Lake City, on Sept. 28, 1876, to Miss Millicent Amelia Godbe, who died in 1889. He was married again on Dec. 15, 1891, to Miss Miriam Godbe, a sister of his first wife. He is survived by his widow and three daughters, Mrs. Clara B. Pitts, Mrs. Miriam B. Jenkins and Mrs. Marjorie B. Riter, all of Salt Lake City.

Mr. Brooks entered the city engineer's office of New Haven, Conn., in the winter of 1870. In the spring of 1872 he went out as field engineer for the Texas & Pacific railroad, traveling from Denver to El Paso overland with mule teams, working from there west to the Pima villages, Ariz. (west of Tucson). A year later he became identified with the city engineer's office of Chicago and helped design the famous waterworks and sewerage system of the city of Chicago, which type of system he was later responsible for starting for the city of Salt Lake. In March, 1874, he formed a partnership with R. H. Browne and opened up the engineering office of Browne & Brooks at Salt Lake. He served as a member of the Salt Lake City board of health from 1890 to 1903; as county surveyor for Salt Lake County from 1891 to 1892; as consulting engineer for the board of public works on the construction of the sewerage system of Salt Lake City from 1888 to 1891; and as a member of the board of public works from 1905 to 1912. He was a United States deputy mineral surveyor for Utah, Idaho, Nevada, and California.

STEPHEN MINOT PITMAN

Stephen Minot Pitman was born in Boston, July 19, 1850, a son of Isaac and Harriet (Minot) Pitman. He was educated in the public schools and for a time attended Brown University, later going to Tufts College, where he received the degree of Ph. B, in 1869. Following his graduation from Tufts he went to Germany, where he pursued special studies in chemistry at the Universities of Heidelberg and Berlin. From 1877 to 1882, he was professor of chemistry at Tufts.

His first business venture was as treasurer and general manager of the Bell Silver & Copper Mining Co., in Butte, Mont., in 1882 and 1883. In 1886, he went to Rhode Island as chemist for the Valley Falls Co. In 1888, he became general manager of the Copp Dyeing Co. He later became secretary of the Philadelphia Manufacturers' Mutual Fire Insurance Co. and was for a time connected with the Holmes Fibre Graphite Co. of Philadelphia. In 1894, he was elected secretary-treasurer of the Narragansett Mutual Fire Insurance Co. of Providence, R. I., and remained in that capacity until he became vice-president, which office he held until his death. He was also a director of the American Investment Co. He was well known in yachting circles, was a member of the A. I. M. E., the Players' Club and the Lambs' Club, in New York. He also belonged to the Theta Delta Chi college fraternity.

Mr. Pitman is survived by a widow, two sons, Laurence Pitman, of Boston and Harold Pitman of New York, and two daughters Mrs. Henry G. Chamberlain, of Boston and Mrs. Sterling Smith of San Diego, Cal.

EDWARD RANDOLPH

Edward Randolph, president of the Balbach Smelting & Refining Co., who died suddenly in his office on Friday, Oct. 11, was born in the city of Memphis, Tenn., Dec. 31, 1870. He came of a family prominent

in the South, his father, Judge William N. Randolph, having been long a distinguished figure in the legal and judicial circles of his section. Edward Randolph studied for the bar, and had already made his mark there when he met Miss Julia Balbach, whom he afterwards married. Her father, the late Edward Balbach, Jr., whose father founded the extensive business later known as Balbach Smelting & Refining Co., recognizing Mr. Randolph's exceptional ability, persuaded him to move to Newark, and in 1898, Mr. Randolph became treasurer of the Balbach Co. A few years later, he was made secretary as well as treasurer of the company, and upon Mr. Balbach's death, in 1910, was the unanimous choice of the directors for the presidency of the institution. This position he occupied with increasing success and distinction until his death.

He was a man of rare personality. With business acumen and ability, he combined qualities which warmly endeared him alike to his employees, his business associates, and a wide circle of friends. In addition to the exacting demands of his large business interests, Mr. Randolph found time for much work of a semi-public nature. He had been especially active in connection with the several Liberty Loans and his activities as chairman of the Committee of Assayers and Refiners continued literally to the hour of his death.

He was a director of the National State Bank of Newark, a member of the Bankers' Club, of the Lotos Club of New York, the New York Athletic Club, Automobile Club of New York, and the Essex Club of Newark. He is survived by his wife; his mother, Mrs. William Randolph, of Memphis; two brothers, George and Wassel Randolph and two sisters, Mrs. Laura Morton and Miss Amy Randolph, all of Memphis.

BRUCE WHITE

Bruce White died of pneumonia following an attack of influenza, at Kootenay Lake General Hospital, Nov. 15, 1918, at the age of 55 years, leaving a wife and two sons. He was a brother of Byron N. White, recently deceased, and of Oscar V. White, now operating mines in the Slocan district, B. C. Born at Ontonagon, Mich., in 1863, and finishing the common schools, Mr. White began mining in 1884, an occupation which he followed without interruption to the time of his death. During this period he mined in almost every State and Territory in which the industry is represented, and of late in British Columbia where he had charge of some important property. For 15 years he was superintendent of the Slocan Star mine at Sandon and more recently managed the Noonday and other properties. His word was taken on mining subjects as being the honest opinion of one well qualified to speak with authority. He had a kindly disposition and his operations were usually successful. He was chairman of the Western Branch, Canadian Mining Institute, for the year 1916–17, and was a member of the American Institute of Mining Engineers.

ELLIOTT HINKLY WILSON

Elliot Hinkly Wilson died, on Nov. 27, at the Warm Springs hospital, Anaconda, Mont., where he was being treated for a malignant affection of the throat. Mr. Wilson was born in New Orleans, La., where his father was proprietor of the St. Charles hotel, on Mch. 15, 1851. He graduated from Washington University, St. Louis, in 1870, making a

remarkable record while a student there, and ranking high in every class. Immediately after his graduation he entered the service of the Mississippi River Commission as one of the engineers dealing with the problem of protecting the lowlands from the floods. There he remained for 3 years, when he enlisted for the work of building the first railroad to tap Montana from the East. He remained with the Northern Pacific for 10 years.

In 1884, he entered into partnership with John Gillie and Wilson & Gillie became one of the best-known firms in the West in mineral surveying and general engineering. The partnership continued until 1898, when Mr. Gillie entered the employ of the Anaconda company. Later Mr. Wilson became affiliated with the Heinze interests and remained with the Heinze organization until 1906. For 3 months in the year 1889, Mr. Wilson served as general manager of the Bi-Metallic Mining Co. at Philipsburg. He served a term in the legislature, was elected a member of the American Institute of Mining Engineers in 1887, and was one of the charter members of the Montana Society of Engineers which was formed in 1887. He was president of the Montana society in 1891. In the last few years Mr. Wilson had devoted himself to private work as an examiner of mining properties for various interests.

Mr. Wilson never married. He is survived by three sisters, Mrs. Mollie S. Smith, Fort Collins, Colo.; Mrs. Nellie Bradford, Waverly, Ill.; and Miss Josie Wilson, Greenville, Ill.

In 1916, 2,362,494 domestic consumers, in twenty States, used natural gas for heat and light and 18,278 industrial concerns used it for fuel.

According to figures furnished by the Minister of Munitions from New Zealand, the output of coal from all New Zealand mines in 1917 was 2,068,419 tons.

Japan exports about $50,000,000 worth of copper a year. It imports ingots and slag from Korea, old copper coins from China, and submarine cables from Great Britain.

It has been estimated that Manchuria has 200,000,000 tons of magnesite ore. Tests have shown it to contain 47.13 per cent. silica, 50.75 per cent. carbonic acid and water, and traces of lime.

In an effort to render itself independent of all other countries for its own supply, Great Britain is now seeking oil near its coal fields. Equipment has been secured from this country to sink ten holes, if necessary, to a depth of 4000 ft. (1219 m.) on the fringe of the Derbyshire coal fields.

In 1918, California led as a gold producing State, the estimate showing 832,389 oz. valued at $17,207,000, while Colorado ranked second with 621,791 oz. valued at $12,853,000. Texas is credited with having produced five oz. valued at $100. Montana with 15,341,000 oz., was the principal silver producing state, while Utah gave 13,439,000 oz., Idaho 10,188,000 oz., and Nevada 10,113,000 oz.

According to the report of the Bureau of Mines, the fatal quarry accidents in the United States average 2.26 per 1000 men employed and the non-fatal injuries 175.62. In the quarries of Belgium, France, Great Britain, and Italy, the fatalities seldom reach 1 per 1000 men per year. In the United States, marble quarries have the lowest rate of fatalities and trap-rock quarries the highest.

LIBRARY

AMERICAN SOCIETY OF CIVIL ENGINEERS
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
AMERICAN SOCIETY OF MECHANICAL ENGINEERS
AMERICAN INSTITUTE OF MINING ENGINEERS
UNITED ENGINEERING SOCIETY
HARRISON W. CRAVER, DIRECTOR

The library of the above-named Societies is open from 9 A. M. to 10 P. M. except on holidays. It contains about 70,000 volumes and 90,000 pamphlets, including sets of technical periodicals and publications of scientific and technical societies.

Members of the Institute, with few exceptions, are forced to spend a portion of their time in localities isolated from sources of information. To these the Library, through its Library Service Bureau, can render valuable service through correspondence; letters requesting information will receive especial attention. The Library is prepared to furnish references and photographic copies of articles on mining and metallurgical subjects; to determine the existence of mining maps, and to furnish general information on the geology and mineral resources of all countries.

All communications should be made as definite as possible so that the information received may be what is desired and not include collateral matter which may not be of interest. The time spent in searching for such collateral matter will be saved, and the information will be sent more promptly and in more usable shape.

Library Accessions

BANK AND PUBLIC HOLIDAYS THROUGHOUT THE WORLD. 1919. (Gift of the Guaranty Trust Company of New York.)

BROTHERHOOD OF MEN AND NATIONS. By John D. Rockefeller, Jr. An address delivered before the Civic and Commercial Club at Denver, June 13, 1918. (Gift of John D. Rockefeller, Jr.)

CHANGING ECONOMIC VIEWPOINTS. (Gift of Guaranty Trust Company of New York.)

DEVELOPMENT OF MAGNETIC SUSCEPTIBILITY IN MANGANESE STEEL BY PROLONGED HEAT TREATMENT. By Charles F. Brush. (Reprinted from Proceedings of the American Philosophical Society, v. 57, 1918.) (Gift of Author.)

ELEMENTS OF EUCLID, VIZ., THE FIRST SIX BOOKS TOGETHER WITH THE ELEVENTH AND TWELFTH. By Robt. Simson. Glasgow, 1756. (Gift of Charles Macdonald.)

THE ETHICS OF COÖPERATION. By James H. Tufts. Boston, 1918. (Gift of University of California Press.)

GOLD. Report of Conference held under the auspices of the Oregon Bankers' Association in Portland, Oregon, Sept. 5, 1918, to consider the gold problem. (Gift of H. N. Lawrie.)

INDUSTRIAL DEVELOPMENT OF INDIA. Nov. 3, 1918. (Gift of Guaranty Trust Company of New York.)

INTERNATIONAL ACETYLENE ASSOCIATION. Annual Convention. 19th, 1917. (Gift of Association.)

MINERAL INDUSTRY. Vol. 26, 1917. New York, McGraw-Hill Book Co., 1918.

PORTLAND CEMENT ASSOCIATION. Magazine List, October, 1918. (Gift of Portland Cement Association.)

THE QUEBEC BRIDGE CARRYING THE TRANSCONTINENTAL LINE OF THE CANADIAN GOVERNMENT RAILWAYS OVER THE ST. LAWRENCE RIVER NEAR THE CITY OF QUEBEC, CANADA. (Gift of George F. Porter.)

ROCKEFELLER FOUNDATION—INTERNATIONAL HEALTH BOARD. Annual Report. 4th, 1917. N. Y., 1918. (Gift of the Foundation.)

SMOKE REGULATION. Compiled by Daniel Maloney. Issued by the Department of Parks and Public Property of the City of Newark, N. J. (Gift of the Department of Parks and Public Property, Smoke Abatement Division, Newark, N. J.)

STEEL ALLOYS CORPORATION. (Gift of Kirby Thomas.)

ARIZONA. State Board of Equalization. Proceedings, 1918. (Gift of the Board.)

CALIFORNIA STATE COUNCIL OF DEFENSE. Report of the Committee on Petroleum. July 7, 1917. Sacramento, 1917. (Gift of California State Library.)

CANADA. Department of Mines. Summary Report of the Mines Branch, 1917. Ottawa, 1918.

MICHIGAN. Department of Labor. Annual Report. 35th, Lansing, 1918. (Gift of the Department of Labor, Mich.)

TASMANIA. Secretary for Mines. Report, 1917. Tasmania, 1918.

U. S. DEPARTMENT OF AGRICULTURE. Bureau of Chemistry. Report of the Chemist. 1918. (Gift of the Bureau.)

U. S. DIRECTOR OF THE CENSUS. Annual Report to the Secretary of Commerce for the fiscal year ended June 30, 1918. Washington, 1918.

UNITED STATES COUNCIL OF NATIONAL DEFENSE. Annual Report. 2d, 1918. Washington, 1918. (Gift of U. S. Council of National Defense.)

U. S. BUREAU OF FOREIGN AND DOMESTIC COMMERCE. Annual Report of the Chief to the Secretary of Commerce for the fiscal year ended June 30, 1918. Washington, 1918. (Gift of the Bureau of Foreign and Domestic Commerce.)

U. S. BOARD OF ORDNANCE AND FORTIFICATION. Annual Report to the Secretary of War. 28th, 1918. Washington, 1918.

U. S. GEOLOGICAL SURVEY. Annual Report of the Director. 39th, 1918. Washington, 1918.

U. S. TREASURY. Director of the Mint. Annual Report for the fiscal year ending June 30, 1918, including Report of the Precious Metals during the calendar year 1917. Washington, 1918.

Book Notices

Unless otherwise specified, books in this list have been presented by the publishers. The Institute does not assume responsibility for any statements made; these are taken from the preface or the text of the book, unless otherwise noted.

AMERICAN ENGINEERS BEHIND THE BATTLE LINES IN FRANCE. By Robert K. Tomlin, Jr. 1st edition. N. Y., published by Engineering News-Record (McGraw-Hill Book Co., Inc., sole selling agents), 1918. 91 pp., illus., 12 × 9 in., ¼ cloth, $2. (Gift of McGraw-Hill Book Co.)

These nineteen articles, reprinted from the McGraw-Hill periodicals of the year, describe various phases of the engineering work executed by the American Army. Gathered together, they form an interesting account of the problems and the methods used to solve them.

AMERICAN PROBLEMS OF RECONSTRUCTION. A National Symposium on the Economic and Financial Aspects. Edited by Elisha M. Friedman, with a foreword by Franklin K. Lane. N. Y., E. P. Dutton and Co., 1918. 23 + 471 pp., 8 × 5 in., cloth, $5.

CONTENTS: Part I. A Perspective of the Question. Part II. Efficiency in Production. Part III. Adjustments in Trade and Finance. Part IV. Programs, Monetary and Fiscal.

The editor here presents the opinions of some twenty-eight prominent Americans, in the hope of stimulating thought on the subject. The specific points treated are the temporary effects of the war, the best methods of facilitating our readjustment to peace conditions, the permanent effects of the war, the changes that these will effect in our national life, and the national economic policy that should be adopted.

ANNUAL CHEMICAL DIRECTORY OF THE UNITED STATES. 2d edition, 1918. Consulting Editor, B. F. Lovelace; Managing Editor, Charles C. Thomas. Baltimore, Williams and Wilkins Co. (copyright 1918). 534 pp., 9 × 6 in., cloth, $5.

This directory is intended as a comprehensive review of all matters relating to industrial, technical, and scientific chemical development in the United States. It contains lists, classified by subject and location, of manufacturers and dealers in chemicals and allied products and in equipment; a geographical directory of industrial, institutional, federal, state, municipal, and commercial laboratories; a list of technical and scientific societies of the world, and bibliographies of technical and scientific journals, and of the important new books of 1917–1918. A "News and Notes" section completes the work. This second issue is approximately twice as large as the first.

THE ATOMIC WEIGHTS OF BORON AND FLUORINE. By Edgar F. Smith and Walter K. Van Haagen. Wash., Carnegie Institution, 1918. 65 pp., 4 illus., 4 tab., 10 × 7 in., paper, $1.

The authors describe in detail their work upon the atomic weight of boron and give a recalculation of that of fluorine, based upon their new value for boron. This latter value is considerably lower than that hitherto accepted.

GRAPHIC CHARTS FOR THE BUSINESS MAN. By Stephen Gilman. Chic., LaSalle Extension University, 1918. 62 pp., 56 illus., 9 × 6 in., paper.

A pamphlet showing the value of charts in presenting statistical data, and describing some of the varieties used in business.

HENDRICK'S COMMERCIAL REGISTER OF THE UNITED STATES FOR BUYERS AND SELLERS. With which has been incorporated "The Assistant Buyer." Especially devoted to the Interests of the Electrical, Engineering, Hardware, Iron, Mechanical, Mill, Mining, Quarrying, Chemical, Railroad, Steel, Architectural, Contracting, and Kindred Industries. A Complete and Reliable Annual Register of Producers, Manufacturers, Dealers, and Consumers Connected with the Aforesaid Industries. N. Y., S. E. Hendricks Co., Inc. (copyright 1918). 2381 pp., 10 × 8 in., cloth, $10.

This register of producers, manufacturers, dealers, and consumers connected with the engineering and industrial activities of the country has been carefully revised and corrected. The firms included are listed alphabetically and also carefully classified. A section containing trade names and brands, with the names of manufacturers, forming a convenient ready reference list for purchasers, is a distinctive feature.

MILL AND CYANIDE HANDBOOK. Comprising Tables, Formulæ, Flow-sheets, and Report Forms, Compiled and Arranged for the Use of Metallurgists, Mill-men, and Cyanide Operators. By W. A. Allen. Lond., Charles Griffin and Co., Ltd.; Phila., J. B. Lippincott Co., 1918. 10 + 128 pp., 7 × 4 in., cloth, $2. (Gift of J. B. Lippincott Co.)

The author has tabulated the physical, chemical, and mechanical data needed by mill-men, in a volume of convenient size, well-indexed. A glossary of mill and cyanide terms is included.

MODERN SHIPBUILDING TERMS DEFINED AND ILLUSTRATED. Including a Series of Photographs Showing the Progressive Steps of Construction, Together with an Appendix on Electric Welding. By F. Forrest Pease. Phila. and Lond., J. B. Lippincott Co. (copyright, 1918). 143 pp., 68 pl., 8 × 5 in., cloth, $2.

This work contains a glossary of the more common words and phrases used in building a steel ship; a list of shipyard trades and the duties performed by each; a series of instruction charts on electric welding; a list of symbols used on plans and parts; a description of the Isherwood system of shipbuilding; directions for the use of acetylene, hydrogen, and oxygen for cutting and welding; and a select list of books on ship construction and equipment. The plates illustrate the construction of a ship by the usual methods, the construction of the "fabricated" ship, and the tools, machines, and installations.

OXWELDING AND CUTTING. Manual of Instruction. [Compiled by the Oxweld Acetylene Company, Jersey City, N. J.] 1st edition (copyright 1918). 124 pp., illus., 8 × 5 in., paper.

The manual describes the apparatus and the methods of using it and gives a series of practice problems illustrating correct methods of meeting those that occur in shops where oxy-acetylene is used for cutting and welding.

MEMBERSHIP

NEW MEMBERS

The following list comprises the names of those persons who became members during the period Dec. 10, 1918, to Jan. 10, 1919.

ADAMS, W. W., Mine Supt., Cia. Minera Paloma y Cabrillas, Higueras, Coah., Mexico.
ANKENY, CLEMENT W., Golden Cycle Min. & Reduction Co., Colorado Springs, Colo.
ARGUE, WILLIAM H............Mech. Engr., Ohio Brass Co., Mansfield, Ohio.
ARTHUR, WALTER..........Chem. and Met., Garford Motor Truck Co., Lima, Ohio.
BANGSER, WILLIAM, Supt., Treatment Dept., Bethlehem Steel Co., Bethlehem, Pa.
BEACH, C. S............Asst. Supt. and Engr., Kemmerer Coal Co., Frontier, Wyo.
BEAVER, A. B., Chem. and Engr. of Tests, National Cash Register Co., Dayton, Ohio.
BORRIES, WILLIAM J., Min. Engr., Gen'l Mgr., American Zinc & Slate Co., Picher, Okla.
BOTSFORD, CLARENCE A., Acting Gen'l Mgr., Mogollon Mines Co., Mogollon, N. M.
BOTSFORD, GEORGE B., Asst. Supt., Sunrise Iron Mines, Colorado Fuel & Iron Co., Sunrise, Wyo.
COLLINS, GEORGE N., Mine Shift Boss, New York & Honduras Rosario Min. Co., San Juancito, Honduras, Central America.
COTÉ, HOMER, Resident Engr., Arkansas and Oklahoma Dist., Central Coal & Coke Co., Huntington, Ark.
CRICHTON, WALTER CREIG, Min. Engr., 208 Charleston National Bank, Charleston, W. Va.
DANFORD, MARK O., Cons. Engr., Danford, Thompson & Douglass, Trinidad, Colo.
GOULD, RICHARD J..........Gen'l Mgr., Elkhornseam Collieries Co., Yeager, Ky.
GRANT, FRANK E., Supt., Steam Shovel Mines, Nevada Cons. Copper Co., Ruth, Nev.
HADLEY, WALTER E............Asst. Gen'l Supt., Illinois Steel Co., Gary, Ind.
HADSELL, WALTER ELIAS....Assayer & Chem., New Cornelia Copper Co., Ajo, Ariz.
HEALD, KENNETH C.......Assoc. Geol., U. S. Geological Survey, Washington, D. C.
HOLMES, GRANT.....................Pres., Robert Holmes & Bros., Danville, Ill.
HORNE, E. B., Mgr., Forge & Foundry, Packard Motor Car Co., Detroit, Mich.
JONES, ARCHIBALD, Met., American Steel & Wire Co., 828 Frick Bldg., Pittsburgh, Pa.
JONES, FRED.........Supt., Portland Mine, Portland Gold Min. Co., Victor, Colo.
KOBAYASHI, KENJI, Min. Engr., Nobori-Kawa Mine, Mitsui Min. Co., Nobori-Kawa, Hokkaido, Japan.
MCGUIRE, JAMES E, Min. Engr............................Grass Valley, Cal.
MCINTYRE, EDWARD E., Cons. Min. Engr., 530 Citizens National Bank Bldg., Los Angeles, Cal.
NELSON, OSCAR L, Structural Engr..............................Denver, Colo.
NICHOLSON, SAMUEL D., Pres., Great Western Min. Co., 806 First National Bank Bldg., Denver, Colo.
OVITZ, FRANK K............Fuel Engr., U. S. Bureau of Mines, Seattle, Wash.
PARSONS, RAYMOND W........Surveyor, North Star Mines Co., Grass Valley, Cal.
PRIMROSE, HARRY S., Met. Chem., Crittall Mfg. Co. Ltd., Manor Wks., Manor St., Braintree, Essex, England.
ROSENSHINE, L. J., Met., Sociedad Esplotadora de Caylloma Consolidada, Arequipa, Peru.
SATO, HISAO, Met. Engr., Kamioka Mine, Mitsui Min. Co., Funatsu, Gifu-ken, Japan.
SMITH, ERWIN WEIR, Asst. Supt. of Operations, Roxana Petroleum Co. of Okla., Box 1235, Houston, Tex.
THOMPSON, HUGH L, Cons. Engr..........................Waterbury, Conn.
THOMPSON, JOHN I., Chief Engr., The Koppers Co., Union Arcade Bldg., Pittsburgh, Pa.
WESTBY, GEORGE C., Met. Engr., U. S. Metal Refin. Co., 120 Broadway, New York, N. Y.
WHEELER, CHARLES H., Supt., Blast Furnaces, Illinois Steel Co., 714 Jefferson St., Gary, Ind.
YOUTSEY, FLOYD STEPHENS, Chief Engr., St. Louis Smelt. & Refin. Works, National Lead Co., St. Francois, Mo.

Associates

BLUE, ARTHUR A. .... 1529 Denniston Ave., Pittsburgh, Pa.
HAMILTON, WILLIAM, Foundry Foreman,
Newport News Shipbuilding & Dry Dock Co., Newport News, Va.
HARTMAN, WILLIAM .... Supt., National Cash Register Co., Dayton, Ohio.
HU, POYUAN .... Asst. Met., Edgewater Steel Co., Oakmont, Pa.
JONES, JESSE L. .... Met., Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.
LEVETT, WALKER M., Pres., Walker M. Levett Co., 415–421 East 23d St.,
New York, N. Y.
NEY, CLYDE MARSHALL .... Min. Engr., Old Dominion Co., Globe, Ariz.
POTTER, G. C. .... Oil Geol., E. N. Gillespie, Box 1875, Tulsa, Okla.
SHAMROTH, C. W. .... 208 E. LaSalle St., Chicago, Ill.
TAPP, EDWARD .... Great Western Smelt. & Refin. Co., Chicago, Ill.
TAYLOR, U., Brass Founder, Robert Taylor & Son, Spring, Slater & Prince Sts.,
Paterson, N. J.
VEATCH, JAMES SIDNEY, Sales Agent, The Ohio Brass Co., 536 Downing St.,
Denver, Colo.
VIVIAN, GEORGE F. .... 2d Lieut., 212th Engineers, Camp Devens, Mass.
WALLACE, ROBERT S. B., Foundry Foreman, National Cash Register Co.,
Dayton, Ohio.
WOOD, JAMES T., JR., Geol. .... White Sulphur Springs, Mont.

Junior Associates

DEUTSCH, H. J. ... Technical Foreman, Aluminum Castings Co., Cleveland, Ohio.
PEART, FREDERICK L., Student, Mass. Institute of Technology, Cambridge, Mass.
SAMOYLOFF, VICTOR ...... Student, Mass. Institute of Technology, Cambridge, Mass.

Change of Status—Associate to Member

JUDSON, W. R., District Mgr., Allis-Chalmers Mfg. Co., Casilla 2653,
Santiago, Chile, South America.

Change of Status—Junior Associate to Member

ZIMMERMAN, S. H., Lieut., Co. A, 107th Engineers, 32d Div., Base Hospital No. 67,
A. P. O. 798, American E. F., France.

Total Membership, Jan. 10, 1919 7177

CHANGE OF ADDRESS OF MEMBERS

The following changes of address of members have been received at the Secretary's office during the period Dec. 10, 1918, to Jan. 10, 1919.

This list together with the list published in Bulletins No. 133 to 145, January, 1918, to January, 1919, and the foregoing list of new members, therefore, supplements the annual list of members corrected to Jan. 1, 1918, and brings it up to the date of Jan. 10, 1919.

ADDAMS, CHARLES E. .... Suncourt Apts., Phoenix, Ariz.
ANDERSON, PAUL SAMUEL, Supt., Falls Creek Min. Co., Granite, Idaho,
via Hope, Idaho.
ARMSTRONG, CLIFTON T. .... Route 6, Danbury, Conn.
BACKUS, GEORGE S., Care Minerals Separation North American Corpn.,
220 Battery St., San Francisco, Cal.
BATES, BENNETT R., Mgr., Mineral Hill Cons. Copper Co., Box 1568, Tucson, Ariz.
BEARD, JOHN W. .... 504 E. Jefferson St., Syracuse, N. Y.
BERNARD, CLINTON P. .... 34 Herriman Ave., Jamaica, N. Y.
BLOSSOM, EDWARD L. .... 63 Wall St., New York, N. Y.
BLUM, E. H., Atlantic Oil Producing Co., American Exchange National Bank Bldg.,
Dallas, Texas.
BOTSFORD, F. P. .... Bennett Mine, Keewatin, Minn.
BRADDOCK, HOMER F. .... Mt. Pleasant, Pa.
BRAIN, ELMER C., Pres., Throndson Metals Savings Co., Box 552, Kellogg, Idaho.
BRUNEL, FRANK P. .... 584 West 15th St., San Pedro, Cal.
BRYANT, GEORGE W. .... Apartado 86, Guanajuato, Mexico.
BRYMER, GEORGE W. .... Hudson Coal Co. Bldg., Scranton, Pa.
BUCHANAN, JEROME R. .... 402 Chamber of Commerce Bldg., Pasadena, Cal.

BUGBEE, EDWARD E., Asst. Prof. of Min., Engr. & Met., Mass. Inst. Technology, Boston, Mass.
BUSH, H. E. .... Engelmine, Plumas County, Cal.
CAPLES, JAMES WATTS, Mine Mgr., The Haynes Stellite Co., Cobalt Camp, Leesburg, Idaho.
CARLSON, A. E. .... 618 9th Ave., W., Ashland, Wis.
CARTWRIGHT, F. O., Chief Clerk, Braden Copper Co., Coya, via Rancagua, Chile, South America.
CHADWICK, LAWRENCE, Plant Street, Charters Towers, N. Queensland, Australia.
CHASE, J. L., International Petroleum Co., Ltd., 56 Church St., Toronto, Ont., Canada.
CLAUSEN, E. H. .... Apt. 6, 1825 Vernon St., N. W., Washington, D. C.
CLEVENGER, G. H. .... 1023 16th St., Washington, D. C.
COGHILL, WILLIAM H., Met., U. S. Bureau of Mines, University Campus, Seattle, Wash.
COHEN, MAXWELL B. .... Meteorological Section, A. P. O., 731 A., American E. F.
COLLINS, GEORGE N., Care Mining & Scientific Press, 420 Market St., San Francisco, Cal.
CORBIN, J. ROSS .... Hotel Green, Danbury, Conn.
CUNNINGHAM, B. L., Cons. Geol., Doheney Pacific Petroleum Co., 1011 Security Bldg., Los Angeles, Cal.
DAVIS, E. W., Office of the Experiment Station, University of Minnesota, Minnesota School of Mines, Minneapolis, Minn.
DEANE, WILLARD A. .... The Dorr Co., Westport, Conn.
DE DEKEN, A. .... Instructed to hold everything.
DIETRICH, W. F. .... Asst. Prof. of Mining, Stanford University, Cal.
EATON, LUCIEN, Supt. of Ishpeming District, Cleveland-Cliffs Iron Co., Ishpeming, Mich.
EICHRODT, CHARLES W., 1st Lieut., Intelligence Service, 151st Inf., 38th Division, American E. F., Care Postmaster, N. Y.
EMMONS, N. H., 2d .... 309 Madison Ave., Lynchburg, Va.
ENDWEISS, J. A., Min. Accountant ...... 842 South Harvard Blvd., Los Angeles, Cal.
EULICH, A. V. .... 472d Engineers, Fort Barrancas, Pensacola, Fla.
EVANS, MILTON R. .... Safety Engr, M. A. Hanna & Co., Wilkes Barre, Pa.
FENTON, CLARENCE M., Care American Rolling Mill Co., Box 1381, Columbus, Ohio.
FINKELDEY, WILLIAM H., Metallographer, Research Division, New Jersey Zinc Co., Palmerton, Pa.
FOLSOM, DAVID M., Mgr., Statistical Dept., General Petroleum Corpn., Alaska Commercial Bldg., San Francisco, Cal.
FRASER, ALEXANDER J. .... Supt., Austerlitz Mine, Arivaca, Ariz.
FRASER, THOMAS .... 1110 West Oregon St., Urbana, Ill.
FRENCH, BURR J. .... West Branch, Mich.
FRY, GEORGE W., Gen'l Mgr., Commonwealth Public Service Co., Merchants National Bank Bldg., Fort Smith, Ark.
FULLER, MYRON L. .... Box 1109, Dallas, Texas.
GAMM, H. F. E. .... 154 Carmita Ave., Rutherford, N. J.
GIBSON, ROBERT W. .... 300 Pine St., Anaconda, Mont.
GILBERT, DONALD C. .... Kennecott Copper Corpn., Kennecott, Alaska.
GRANT, ULYSSES S., IV .... 27 West 44th St., New York, N. Y.
GUYER, RAYMOND, Gen'l Mgr., Rex Cons. Mining Co., 218 Symons Bldg., Spokane, Wash.
HAMANN, W. A., JR. .... 118 Urban St., Mount Vernon, N. Y.
HAMBLETON, JAMES W., Min. Engr. & Ore Buyer, Cons. Engr., International Exchange & Commission Co., 212 West 2d St., El Paso, Texas.
HAMILTON, WALTER R. .... Pomeroy & Hamilton, 803 Mayo Bldg., Tulsa, Okla.
HARRISON, G. E. .... Care The McKinney Steel Co., Crystal Falls, Mich.
HAYDEN, WALLACE H. .... 101 North St., Batavia, N. Y.
HEDGES, J. H. .... Prince Cons. M. & S. Co., Pioche, Nev.
HENNIGER, WALDEMAR F. .... Pet. Geol., Gulf Production Co., Fort Worth, Texas.
HERZ, NATHANIEL .... 45 Sheldon Terrace, New Haven, Conn.
HIGASHI, SENTARO, Mitsubishi Kogyo Kenkiusho, Gongendai, Shinagawa, Tokyo, Japan.
HILL, WALTER H. .... 712 Hays St., Boise, Idaho.
HILL, WILLIAM J. .... 2d Lieut., School of Fire, Fort Sill, Okla.
HINES, P. R. .... Min. Dept., Allis Chalmers Mfg. Co., Milwaukee, Wis.
HODGKINSON, HAROLD H. .... 30 West 44th St., New York, N. Y.

HOSKIN, ARTHUR J. .... 411 Chamber of Commerce Bldg., Denver, Colo
HOULE, ALBERT J., Min. Engr., Morenci Branch, Phelps-Dodge Corpn., Morenci, Ariz.
HOUSER, J. N. .... American Zinc, Lead & Smelt. Co., Mascot, Tenn.
HYDER, FREDERICK BOREN, Min. Engr., U. S. Bureau of Mines,
Room 2114, New Interior Bldg., Washington, D. C.
JESS, JOHN A. .... Cons. Engr., Forest Products Laboratory, Madison, Wis.
JOHNSTON, FRED LUCIAN, Div. Engr., Acid Div., Du Pont Engineering Co.,
Wilmington, Del.
KENDALL, MESSMORE .... 120 Broadway, New York, N. Y.
KICHLINE, FRANK O. .... Lebanon Plant, Bethlehem Steel Co., Lebanon, Pa.
KOHL, E. WILLIAM, JR. .... 1522 West Lehigh Ave., Philadelphia, Pa.
KONSELMAN, ALBERT S. ...... Cananea Cons. Copper Co., Cananea, Sonora, Mexico.
KRAUT, MAX, Met. & Min. Engr., Southwestern Engineering Co., Inc.,
1221 Hollingsworth Bldg., Los Angeles, Cal.
KROEGER, ADOLPH C. .... 455 Vernon St., Oakland, Cal.
LADOO, RAYMOND B., 2322 Massachusetts Ave., Cambridge, Mass.
Care F. A. Keniston.
LANE, JAMES A., Sgt., Headquarters Co., 11 Regt., U. S. Marines,
American E. F., Care Postmaster, N. Y.
LASNER, DAVID .... 423 Bond St., Elizabeth, N. J.
LAUGHLIN, S. W. .... Box 163, Miami, Ariz.
LESNIAK, S. W., Great National Mexican Smelt. Co., La Reforma, Coah.,
Est. San Juan, via Cuatro Cienegas, Mexico.
LOCKE, PRESTON, Resident Min. Engr., American Smelting & Refin. Co.,
705–6 White Bldg., Seattle, Wash.
LOVE, JAMES W., Lieut., 347th Field Artillery, American E. F., Care Postmaster, N. Y.
LUCKY, M. C., JR., 1st Lieut., 4th Div., 47th Infantry, American E. F.,
Care Postmaster, N. Y.
LUPTON, CHARLES T. .... Box 1106, Casper, Wyo.
LYONS, ROBERT P., 1st Lieut., 525th Engineers, American E. F.,
Care Postmaster, N. Y.
McCRORKEN, EUGENE P., Ensign, Naval Aviation, Bureau of Steam Engrg.,
Washington, D. C.
MACFARLAND, A. FREDERIC .... 1125 North Pine Ave., Chicago, Ill.
MACY, G. D. .... The Ohio Cities Gas Co., Sistersville, W. Va.
MARBLE, RALPH N., JR. .... Mahoning Ore & Steel Co., Hibbing, Minn.
MARTIN, JACOB A. .... 2047 Carabell Ave., Cleveland, Ohio.
MERRITT, FLOYD C., Aetna Mining & Investment Co., 321 Felt Bldg.,
Salt Lake City, Utah.
MEYERS, WILLIAM R., 1st Lieut., Engr. R. C., American E. F.,
Care Postmaster, N. Y.
MILLER, ARTHUR J., Stimpson Equipment Co., 318 Felt Bldg., Salt Lake City, Utah.
MILLER, DONALD G. .... Tyrone, N. M.
MILYKO, ALEXANDER .... 946 College Ave., New York, N. Y.
NAKAMURA, HAJIME .... Furukawa Mining Co., Marunouchi, Tokyo, Japan.
NICHOLSON, FRANCIS .... Joplin, Mo.
NIEDING, BURTON B. .... Care United Verde Extension Co., Jerome, Ariz.
NORTH, ALFRED C. .... Instructed to hold everything.
NORTON, PAUL T., JR. .... Hotel Seneca, Columbus, Ohio.
OFFICER, HERBERT G. .... 4 West 43d St., New York, N. Y.
OLMSTEAD, S. G. .... Room 412, Dooley Block, Salt Lake City, Utah.
O'NEALE, M. L. .... Mine & Mill Supt., New York Pyrites Co., Gouverneur, N. Y.
PALMER, CHARLES H., JR. .... Capt., Engr. Corps, U. S. A., Washington, D. C.
PARKE, WILLIAM G. .... Room 205–7, 114½ West Market St., Pottsville, Pa.
PATTERSON, S. B., JR. .... 138 North 8th St., Allentown, Pa.
PEMBROKE, EARL RICHARD .... Kearns Bldg., Salt Lake City, Utah.
PERRY, RALPH G. .... 905 West California St., Urbana, Ill.
PLATT, JAMES M. .... Care Cia. Min. La Blanca y Anexas, Pachuca, Hgo., Mexico.
PRICE, HARRY B. .... 228 Pemberton Bldg., Victoria, B. C., Canada.
RANDALL, CHARLES A., Mgr., Dome Lake Min. & Mill. Co., Ltd.,
South Porcupine, Ont., Canada.
READ, J. BURNS, Capt., Ord. R. C., Inspection Div.,
3120 Mount Pleasant Ave., N. W., Washington, D. C.
READ, THOMAS T. .... 594 Upper Mountain Ave., Montclair, N. J.
REBER, W. H., Warrant Machinist, U. S. Navy Steam Engr. School, Hoboken, N. J.
REED, CHARLES H. .... Urad Mine, Primos Exploration Co., Empire, Colo.

RETTIE, WILLIAM HENDERSON, Forminiere, Tshikapa, Kasai, Congo Belge, Africa.
REYNDERS, JOHN V. W. .... Room 3048, 120 Broadway, New York, N. Y.
RICHARDS, GEORGE M., Min. Engr. .... 28 West 46th St., New York, N. Y.
ROBINSON, E. W. .... 720 Ernest & Cranmer Bldg., Denver, Colo.
RORK, FRANK C. .... Box 442, Clifton, Ariz.
RUEBEL, E. H., Chief Chem., National Zinc Co., Packers Station, Kansas City, Kansas.
SACKET, CHARLES T. .... Major, 213th Engineers, Camp Lewis, Wash.
SAPPER, C. FLOYD .... Hercules Powder Co., Kennil, N. J.
SAWYER, ARTHUR H. .... 689 Mass. Ave., Cambridge, Mass.
SCHEURER, L. R. .... Box 529, Rolla, Mo.
SCHLEIFER, K. A. .... 809 Bloomfield St., Hoboken, N. J.
SCHMIDT, CASPAR ANTHONY .... Box 1860, Denver, Colo.
SCHMIDT, HENRY C. .... The Rosemont, Apt. 12, El Paso, Texas.
SCHOFIELD, WALTER D. .... 2 Colchester Apts., Colorado Springs, Colo.
SEMPLE, C. CARLETON .... Peruvian Copper & Smelt. Co., Jauja, Peru.
SHAW, S. F. .... 226 Argyle Ave., San Antonio, Texas.
SILVESTER, GEORGE E., Asst. to Pres., International Nickel Co. of Canada, Ltd., Harbor Commission Bldg., Toronto, Ont., Canada.
SMALE, FRANK L. .... 703 26th Street, San Diego, Cal.
SMITH, BERT F. .... Care Creede Exploration Co., Creede, Colo.
SMITH, VELEAIR C., Min. Geol. and Asst. Assayer, Lucius Pitkin Inc., 47 Fulton St., New York, N. Y.
SNOW, FREDERICK W., Care U. M. H. K., Elisabethville, Katanga, Congo Belge, Africa, via Cape Town & Rhodesia.
SPENCER, MARSHALL G., Electric Steel Co. of Indiana, Box 327, Indianapolis, Ind.
STADTMUELLER, KARL C. .... 34 Girard Ave., Hartford, Conn.
STEPHENSON, E. A. .... 5485 Ellis Ave., Chicago, Ill.
STICKNEY, ALFRED W., Care Irtysh Corporation, Pinners Hall, Austin Friars, London, E. C. 2, England.
STRATTON, WILLIAM C. .... 110 North Chestnut St., Scottdale, Pa.
SULLIVAN, CLARKE .... 5835 Ocean View Drive, Oakland, Cal.
SWEETSER, ARTHUR L., Min. & Chem. Engr., The Penyon Syndicate, Antofagasta, Chile.
THOENEN, J. R. .... Supt., Indiana Fluorspar & Lead Co., Evansville, Indiana.
THOMPSON, WARREN D. .... Harvard Club, 27 West 44th St., New York, N. Y.
THURMOND, F. LEROI .... 3008 Alki Ave., Seattle, Wash.
THURSTON, E. COPPÉE .... 6804 Brookville Road, Chevy Chase, Md.
TOYODA, HIDEKANE, Furukawa Min. Co., Marunouchi, Kojimachi-ku, Tokyo, Japan.
TRIPLETT, WALTER H. .... 5727 Colorado Ave., Washington, D. C.
TSAI, HSIANG .... Han-yeh-ping Iron & Coal Co., Ltd., Tayeh, China.
TURNER, ALBERT A. .... Britannia Mining Co., Cuba 71, Havana, Cuba.
VAN SICLEN, MATTHEW .... 136 West 44th St., New York, N. Y.
VELASCO, L. I. .... 2613 Maryland Ave., Baltimore, Md.
WAECHTER, I. EDMUND ...... Chem. & Met., Carnegie Steel Co., Youngstown, Ohio.
WALKER, W. LESTER .... 608 Carter Bldg., Houston, Texas.
WARREN, S. POWER, Mill Supt., The Colorado Central Mines Co., Georgetown, Colo.
WEEKS, L. G. .... Min. Geol., Chilton, Wis.
WELLMAN, W. H. .... Supt. Concentrator, 85 Mining Co., Valedon, N. M.
WHEELOCK, C. E. .... C. Q. M. Naval Proving Ground.
WHITE, JOSEPH L. .... Field Engr., Cons. Arizona Smelt. Co., Humboldt, Ariz.
WICKSTROM, CLARENCE L. .... 415 16th Ave., North, Seattle, Wash.
WILLIAMS, EDWARD I., Min. Engr., General Chemical Co., 25 Broad St., New York, N. Y.
WILLIAMSON, F. O., Western Sales Mgr., Smith Engr. Works, and T. L. Smith Co., 545 Old Colony Bldg., Chicago, Ill.
WILLSON, HAROLD E., Civ. and Min. Engineer .... Quinnimont, W. Va.
WISER, OBA .... Pres., Republic Min. & Mill. Co., Hanover, N. M.
YARDLEY, JOHN L. McK., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
YATES, A., 14 Winchester Ave., Sedgley Park, Prestwich, Manchester, England.
YEATMAN, POPE .... 1118 Spruce St., Philadelphia, Pa.
YEWELL, P. R. .... Student, Stanford University, Cal.
ZIEGLER, FRANK K. .... Bee Ridge, Fla.

MEMBERS' ADDRESSES WANTED

Name.	Last address of Record from which Mail has been returned.
ARMSTRONG, E. W.	Mina Bibilonia, La Libertad, Nicaragua, C. A.
BACON, MAURICE W.	726 Old National Bank Building, Spokane, Wash.
BIRD, FRANK H.	Butler Hotel, Seattle, Wash.
BLANCHARD, RALPH C.	3 Lombard St., London, England.
BOYER, SAMUEL L.	San Francisco, Cal.
BREEDING, F. O.	Eden Min. Co., Bluefields, Nicaragua.
DETERT, WILLIAM F.	Jackson, Amador Co., Cal.
HERR, J. CAMPBELL	Box 556, State College, Pa.
HUGHES, WILSON W.	Care Lloyd's Bank, Forrey, Cornwall, Eng.
HUNTER, CHARLES	Royal Colonial Institute, Northumberland Ave., London, W., England.
HURUM, FREDRIK J. O.	Westmorley Court, Cambridge, Mass.
KAMMERER, CHARLES	Box 412, San Francisco, Cal.
KAY, DAVID NELSON	Ray Cons. Copper Co., Hayden, Ariz.
KING, FRANK E.	Hotel Breslin, New York, N. Y.
KLEESATTEL, RICHARD	911 White Bldg., Seattle, Wash.
KLUGESCHEID, WALTER P.	616 W. 113th St., New York, N. Y.
STICKNEY, WILLIAM H.	708 N. Center St., Reno, Nev.
TAPLIN, THOMAS J., JR.	16 Lordship Park, London N. 16, England.
TINGLEY, T. W.	Beutree, W. Va.
TREAT, LLOYD B.	Canadian Ingersoll-Rand Co., Bank of Toronto Bldg., Montreal, Canada.
WONG, YIN CHARLES	Rolla, Mo.
WOO, W. K.	M 70 Sing Kong Li, Minghong Road, Shanghai, China.

NECROLOGY

(See also "Died in Service")

The deaths of the following members were reported to the Secretary's office during the month Dec. 10, 1918, to Jan. 10, 1919.

Date of Election.	Name.	Date of Death.
1914	Barren, Harry B.	Mar. 18, 1918.
1917	Brook, N. W.	Oct. 24, 1918.
1895	Carter, Palmer	Dec. 4, 1918.
1915	Harbach, Herbert Moore	Dec. 6, 1918.
1893	Johnson, Charles H.	Dec. 10, 1918.
1916	Lang, Sidney A.	Oct. —, 1918.
1881	McLanahan, J. King	Dec. 13, 1918.
1913	Pitman, S. M.	Dec. 16, 1918.
1914	Potter, Winfield S.	Jan. 3, 1919.
1902	Randolph, Edward	Oct. 11, 1918.
1871	Raymond, R. W.	Dec. 31, 1918.
1914	Rodgers, S. M.	Sept. —, 1918.
1917	Schubert, Robert	Sept. 7, 1918.
1888	Stein, Walter M.	Sept. 10, 1918.
1914	Steindler, Eugene L.	Oct. 2, 1918.
1917	Stewart, A. K.	Nov. 22, 1918.
1887	Wilson, Elliott H.	Nov. 27, 1918.
1880	Woodbury, L. S.	Nov. 27, 1918.

CANDIDATES FOR MEMBERSHIP

APPLICATION FOR MEMBERSHIP.—The Institute desires to extend its privileges to every person to whom it can be of service. On the other hand, it is not desirable that persons should be admitted to membership in classes for which they are not qualified. Members of the Institute can be of great service if they will make a practice of glancing through the list of applicants and promptly notifying the Committee on Membership, or the Secretary of the Institute, of any persons whom they think should not be classified in accordance with the list given.

Applications Lacking Endorsement

Application for membership has been received from Mr. Brink, whose record is given below. This application lacks the necessary number of endorsers, but since this candidate lives at some distance from the headquarters of the Institute, his record is published here in order that any members who are acquainted with him may be advised of the circumstances and may have an opportunity of writing to the Secretary endorsing this candidate.

Members

Cyril Gordon Brink, Transvaal, So. Africa.
Born 1889, Grahamstown, So. Africa. 1900–05, High School. 1906–07, St. Andrews School. 1908–09, Chem., Rhodes Univ., Grahamstown. 1910–15, In Reduction Wks., Norse Gold Mines, Ltd., Johannesburg. 1915–17, Leading Shiftsman, and in chg. of reduction wks., Fairview gold mine, Transvaal Cons. Mines.
Present position—1917 to date: Reduction Officer, Fairview Devonian Montrose Gold Mines, Ltd.

The following persons have been proposed during the period Dec. 10, 1918, to Jan. 10, 1919, for election as members of the Institute. Their names are published for the information of Members and Associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Board of Directors, which has the power of final election.

Carlos Alayza y Roel, Lima, Peru.
Proposed by Myron R. Walker, J. H. W. Murdock, Luis F. Diaz.
Born 1878, Lima, Peru. 1895–1900, School of Engineers of Lima. 1901, Prospecting. 1902–04, Assayer and Engr., Cia. Cailloma Silver Min. Co. 1904, Study of the highway from Iroya to Farma. 1905, Study of the railroad from Jonan to Magdalena, as Adjutant. 1905–07, Mgr., El Ebro mine. 1907–09, In chg. of mine of the Deligacion de Huancayo. 1910–12, Inspector of coal mines, Goyllarisquisga and Quishuarcancha.
Present position—1912 to date: Mgr., Cia. Miniere Rosario y San Lorenzo.

Maurice Ernest Altmayer, Paris, France.
Proposed by H. O. Hofman, Carle R. Hayward, Charles E. Locke.
Born 1871, Paris, France. 1895, Ecole Centrale des Arts et Mfrs. 1896–99, Various positions in mines in U. S. and Mexico. 1899–1902, Electrometallurgy, Leeds Copper Works, England. 1902–07, Cons. Engr., Algeria and France. 1908–12, Managing Director of company connected with mining in the French colonies.
Present position—1912–18: On staff of consulting engineers of the Bank of Paris, and Pays Bas, Rue d'Antin.

James Jefferson Beaver, Bessemer, Ala.
Proposed by Clarence E. Abbott, H. S. Salmon, Carl F. Schaber.
Born 1886, Oakman, Ala. 1906–10, Alabama Polytechnic Inst., B. S. 1910–11, Transitman. 1911–12, Asst. Mine Foreman. 1912, Transitman and Asst. Engr., W. I. Co., Bessemer, Ala. 1912–13, Rodman and drafting. 1913, Asst. Engr., Constr., and Rodman. 1913–17, Transitman and Asst. Engr., Tennessee Coal Iron & R. R. Co., Bessemer, Ala.
Present position—1917 to date: Div. Engr., Tennessee Coal Iron & R. R. Co.

Henry Graham Boulton, Seattle, Wash.
Proposed by Milnor Roberts, Henry Landes, Charles E. Weaver.
Born 1893, Russell, Manitoba, Can. 1917, Univ. of Washington, Seattle, Wash., B. S. 1909–11, Draftsman in offices of Somervell & Cote, architects, Seattle. 1916, Mining, Standard Mine, Greenhill Cleveland Co., Mace, Idaho. 1917, Asst. Geol., Canadian Geol. Survey, in Yukon Terr., Canada. 1918, Min. Engr., Mackey Min. Co., Newsome, Idaho; head offices 1540 W. 46th St., Seattle, Wash.
Present position: Engaged at steel shipbuilding plant, Skinner & Eddy Corp.

Milton Kerr Campbell, Jr., Pomona, Cal.
Proposed by Frank L. Stack, Don C. Billick, A. B. Foote.
Born 1891, Harlan, Iowa. 1908–09, Tabor College, Tabor, Iowa. 1909–14, Univ. of California, B. S. 1911, Oiler on gold dredges, Natomas Consolidated, Natomas, Cal. 1912, Underground work, North Star mine, Grass Valley, Cal. 1912–13, Cost accountant and mine bookkeeper, Midas Gold Min. Co., Knob, Shasta County, Cal. 1914, Asst. Engr. and Assayer, North Star mine, Grass Valley, Cal. 1914–15, Asst. to Supt., Estaca Min. Co., Contra Estaca, Sinaloa, Mex. 1915–16, Shift boss, San Luis Min. Co., Tayolita, Durango, Mex. 1916, Asst. Engr., North Star mine, Grass Valley, Cal. 1916–17, Sampling Inspector, Backus & Johnston Co., Casapalca, Peru. 1917–18, Foreman, leaching plant and blast furnace, Chile Exploration Co., Chuquicamata, Chile.
Present position: Warrant Machinist, U. S. N. A.

Joseph S. Comerford, Wilmington, Del.
Proposed by A. S. Hummell, John H. Hall, Clement Le Boutillier.
Born 1891, U. S. A. 1908, High School, High Bridge, N. J. 1912, Grad., General Chem., International Correspondence School. 1908–11, First Asst. Chem., Taylor-Wharton Iron & Steel Co., High Bridge, N. J.
Present position—1911 to date: Chem. and Met., American Manganese Steel Co., New Castle, Del.

W. G. Cooper, Stanford University, Cal.
Proposed by J. F. Newsom, C. F. Tolman, Jr., D. M. Folsom.
Born 1891, Eureka, Cal. 1909–14, Stanford Univ., A. B. 1912–14, Asst. in Mineralogy, Stanford Univ. 1914–15, Field Engr., Yukon Gold Co., Alaska. 1916–18, Field Engr., Société Forestière et Minière du Congo, Africa.
Present position: Engaged in petrographic work, Stanford University.

Shepard Gilbert Emilio, Bingham Canyon, Utah.
Proposed by T. A. Janney, J. A. Norden, V. S. Rood.
Born 1885, Salem, Mass. 1903–07, Grad., Mass. Inst. Tech., S. B. 1907–08, Asst. Engr., gen'l engrg. office and field work, Old Dominion Copper Min. & Smelt. Co. 1909, Cost Clerk and some chemical analysis, Independent Foundry, Portland, Ore. 1909–15, Intermittently employed, gen'l engrg. office and field work in railroad and canal location and construction and land surveying, etc., Oregon Lumber Co., Mt. Hood R. R., Dee Irrigation & Power Co., West Bros. 1916, Asst. Engr., Shift Boss, Asst. to Mine Foreman, Engr., Utah Apex Min. Co., Bingham, Utah.
Present position: Min. Engr., Utah Apex Min. Co.

Francis Benedict Foley, Pittsburgh, Pa.
Proposed by Charles Y. Clayton, Dorsey A. Lyon, H. Foster Bain.
Born 1887, Germantown, Pa. 1894–1904, Girard College. 1905–09, Clerical. 1909–17, Research Dept. 1913–17, Charge of heat treating, photomicrography, pyrometric installation, and thermal analysis, Midvale Steel Co., Philadelphia, Pa. 1917–18, Asst. in Dept. of Metallography, Univ. of Minnesota.
Present position—1918 to date: Met., U. S. Bureau of Mines.

Nathan Henry Gellert, Wayne, Pa.
Proposed by C. W. Van Law, Albert A. Heimrod, Linn Bradley.
Born 1889, Baltimore, Md. 1910, Yale University, B. A., also hold Ph. B. and C. E. 1914–16, Graduate work, Yale Univ. 1910–14, American Gas Co. of Phila., Chester, Pa. and Jenkintown, Pa. 1911–12, Asst. Engr., Whetstone & Co.; Chief Engr., Key West Gas Co. 1912–14, Engr., Public Service Construction Co., San Juan, P. R. 1914, Mngng. Engr., International Gas & Electric Co. 1916–17, Hess-Ives Corporation. 1917–18, Cons. Engr.
Present position—1918 to date: Pres., Gellert Engineering Co.

Moushegh Horhanness Geumlek, Tyrone, N. M.
Proposed by Frank B. Harris, Stephen L. Kaffer, Eugene N. Sawyer.
Born 1893, Marsovan, Armenia. 1909–12, Anatolia College. 1914–16, Wisconsin Mining School. 1916–17, Millman, Sally Mining Co., zinc and lead concentration plants. 1917, Millman, Vinegar Hill Zinc Co.
Present position—1917 to date: Mine Engineer, Phelps-Dodge Corporation, Burro Mountain Copper Co. Branch.

Millard F. Gibson, Toronto, Ont., Canada.
Proposed by George R. Rogers, Reginald E. Hore, C. W. Knight.
Born 1883, La Peer, Mich. 1909, Ohio State Univ., C. E. 1902–09, Research work; and with Columbus Hocking Coal & Iron Co., mine surveys and fuel reports, National Fire-proofing Co. 1909–10, Installation, producer gas-fired plants. 1910–12, Gen'l Supt., mines and factories, National Fire-proofing Co., Ohio. 1912–16, Gen'l Supt., National Fire-proofing Co., Canada.
Present position—1916 to date: Gen'l Mgr., National Fire-proofing Co. of Canada.

Wilbur Henry Grant, San Francisco, Cal.
Proposed by J. E. Spurr, Bulkeley Wells, Roy H. Elliott.
Born 1879, Aurora, Ill. 1887–99, Public Schools, West Aurora. 1902–04, Univ. of Michigan. 1904–06, Michigan College of Mines, E. M. 1906–08, Instructor, Dept. of Geol., Michigan College of Mines. 1908, Min. Engr., Mascot Min. Co., Klondyke, Ariz. 1909, Min. Engr., Arizona Commercial Copper Co., Globe, Ariz. 1909–11, Geol., Spurr & Cox, Inc., New York, N. Y. 1912–13, Geol., American Smelt. & Refin. Co., New York, N. Y.
Present position: Cons. Min. and Geol. Engr.

Frank Hastings Haller, Osceola, Mich.
Proposed by John Knox, C. H. Benedict, R. McIntosh.
Born 1874, Lanark, Ill. 1892–98, Northwestern Univ., Ph. B. 1900–01, Michigan College of Mines. 1903–06, Min. Engr., Oliver Iron Min. Co., Ironwood, Mich.
Present position—1906 to date: Supt., Osceola Cons. Min. Co.

Richard Daniel Hatton, St. Louis, Mo.
Proposed by Fred L. Wolf, L. W. Olson, W. M. Corse.
Born 1874, St. Louis, Mo. Attended St. Louis Univ. 1892 to date, Laclede-Christy Clay Products Co. 1907, Sec. and Treas. 1911, Vice-pres. and Gen'l Mgr.
Present position: Vice-pres., Laclede-Christy Clay Products Co.

I. Berkwood Hobsbawn, Valparaiso, Chile, S. A.
Proposed by John V. N. Dorr, H. N. Spicer, D. S. McAfee.
Born 1885, London, England. 1901, Diploma, Manchester School of Technology, Faculty of Technology, Victoria Univ., England. 1902–04, Asst. Research Chem., Levinstein, Ltd., Manchester. 1904–05, Asst. Mgr., James Wilberson & Sons, Sheffield. 1905–08, Research Chem. and Analyst, A. Boabe Roberts & Co., Ltd., London. 1908–11, Advising Chem. in Chile, Lockett Bros. & Co., Liverpool.
Present position—1912 to date: Cons. Tech. Adviser, Gibbs & Co.

Sakaye Kato, New York, N. Y.
Proposed by Joseph W. Richards, Charles L. Huston, Willard S. Morse.
Born 1878, Chiba, Japan. 1898–1901, Kyoto Imperial Univ., Japan, M. E. 1901–05, Apprentice and Asst. Engr., Roll. Mill Dept.; 1905–08, Supt. of Rolling Mill Dept.; 1908–10, Chief Inspector and Head of Mechanical Laboratory, Imperial Steel Works, Japan. 1910–17, Chief Mech. Engr., Kosaka Copper Mine, Japan.
Present position—1918 to date: Mgr. of Sumitomo Copper Works, Osaka, Japan.

Daniel Grant Kidder, Los Angeles, Cal.
Proposed by Frank P. Mills, Andrew Carrigan, C. O. Lindberg.
Born 1869, Reading, Mich. 1886, High School, Reading, Mich. 1887, Normal, Valparaiso, Ind. 1891, Cleary Business College, Ypsilanti, Mich. 1892–93, Stenographer, Tamarack-Osceola Copper Mfg. Co., Dollar Bay, Mich. 1893–95, Asst. Paymaster and Bookkeeper, Tamarack Copper Min. Co., Calumet, Mich. 1895–1902, Chief Clerk, Merced Gold Min. Co., Coulterville, Cal. 1902–04, Supt., Merced Gold Min. Co., Coulterville, Cal. 1904–16, Examining and Cons. Engr., operating and reporting, surveying, geology and mineralogy, mines and oil. 1916–18, Gen'l Supt. and Cons. Engr., Union Metals Corpn.; United Tungsten Copper Mines, Arizona and Cal.
Present position: Unattached.

Luther Loucine Knox, Pittsburgh, Pa.
Proposed by John S. Unger, C. F. W. Rys, Hugh P. Tieman.
Born 1870, Pulaski, Pa. 1876–88, Common School, Pulaski, and St. Joe, Butler County, Pa. 1889–90, Mount Union College. 1890, '91, '92, Alleghany College. 1890–93, Civil Engr. with G. A. Gilfillan, Pittsburgh, Pa. 1893–94, Traveling Salesman, C. P. McCurdy, Meadville, Pa. 1894–96, Draftsman, Jones & Laughlin Steel Co. 1896–98, Draftsman, shifter bridge, Pittsburgh & Lake Erie R. R. Co. 1900–01, Supt. of Construction, Sharon Steel Co., Farrell, Pa. 1901–02, Charge of designing, detailing, erection, open-hearth plants, Riter-Conley Mfg. Co. 1902–03, Consulting engr., Mgr., M. H. Treadwell Co., Pittsburgh. 1903–04, Partner, Grove & Knox, Mfg. Agts. and Engrs. 1905, Supt., Engr. and Mgr., National Metallurgical Plant, Hackensack River & Plank Rd., N. J. 1906, Chief Engr., Clara Furnace, Cherry Valley Iron Co., West Middlesex, Pa. 1906–08, Vice-pres. and Mgr., Knox-Murray Co.
Present position: Pres., Hydraulic Drawn Forging Co.; Vice-pres., Blaw-Knox Co., Keystone Bronze Co.

William Koerner, Imlay, Nev.
Proposed by Walter H. Aldridge, William C. Browning, E. H. Lunquist.
Born 1886, Oregon City, Ore. 1904–08, Stanford Univ., A. B. 1909, Sampler, Ray Cons. Copper Co. 1909–11, Sampler, Mine Surveyor, Inspiration Copper Co. 1912–13, Mine Surveyor and Assayer. 1913–14, Supt., Barker Mines Co. 1914–15, Mine Surveyor, Creston Colorado Mine Co. 1915, Mill Shift Boss, Magma Copper Co. 1915–16, Field Engr., Mason Valley Mines Co. 1916–18, Supt., Gray Eagle Copper Co.
Present position—1918 to date: Supt., Majuba Hill mine of Mason Valley Mines.

Charles Raymond Küster, Benton, Wis.
Proposed by Ralph E. Davis, W. R. Smith, W. N. Smith.
Born 1891, Platteville, Wis. 1910, Grad., Wisconsin State Min. School, Platteville, Wis. 1910–11, Underground work, Vinegar Hill mine. 1911–12, Timekeeper, Vinegar Hill Zinc Co. 1912–18, Supt. of various mines, Vinegar Hill Zinc Co.
Present position: Supt., Meloy mine.

Edmund Leslie Laing, Iron River, Mich.
Proposed by J. Murray Riddell, W. O. Hotchkiss, Charles R. Lawrence.
Born 1889, Gladstone, Mich. 1907–09, Michigan College of Mines. 1910, Asst. Min. Engr., Munro Iron Min. Co., Iron River, Mich. 1910–12, Michigan College of Mines, B. S. and E. M. 1912, Miner, Zimmerman mine, Iron River, Mich. 1912–18, Independent min. engrg. practice.
Present position: Min. Engr.

William David Mainwaring, W. Philadelphia, Pa.
Proposed by James H. Herron, Zay Jeffries, Joseph W. Richards.
Born 1879, Maline Lee, England. 1897–1901, Post Graduate work, Drexel Institute. 1903–12, Private tutors in mech. drawing and mathematics; metallography of iron and steel, under Albert Sauveur; private tutor, thermo-chemistry, met. calculations. 1896–1902, Open-hearth Clerk to Asst. to Chief Chem., Pencoyd Iron Wks. 1902–14, Chem. and Met., Railway Steel Spring Co. 1914–16, Associated with cons. engrs., Cleveland, Ohio.
Present position—1916 to date: Chem. and Met. Engr.

Harvey Mathews, Empire, Colo.
Proposed by Charles A. Chase, Harold Boericke, Charles H. Reed.
Born 1890, Salina, Kans. 1905–09, Centennial High School, Pueblo, Colo. 1909–13, Grad., Colorado School of Mines, Golden, Colo., E. M. 1913–14, Repairs, operation, experimental work, Ohio Copper Co. 1914, Repairs, Chino Copper Co. 1914–15, Shift Boss, refinery man, Ernestine Mines Co., Mogollon, N. Mex. 1915–17, Supt., cyanide plant, Bonanza mine, Bluefields, Nicaragua. 1917–18, Engr., Tonopah Nicaragua Min. Co., Bluefields, Nicaragua.
Present position—1918 to date: Mill Supt.. Primos Exploration Co.

Fred William Nash, San Diego, Cal.
Proposed by Ben. H. Cody, Henry A. Tobelmann, L. D. Ricketts.
Born 1872, Wadsworth, O. 1877–86, Grammar School, Akron, O. 1894–1903, Studied min. engng., assaying, met. and chem. in spare time. 1886–93, Bookkeeper, Accountant, Commercial Telegraph Operator, J. F. Seiberling & Co.; Asst. Mgr., Diamond Rubber Co., Akron. 1894–1903, Special Representative, Colorado and Wyoming, Phoenix Mutual Life Ins. Co., Hartford, Conn. 1903–05, Interested in Waldorf Cons. M. & M. Co., Georgetown, Colo.; organized Manhattan Union Min. Co. 1905, Opened ore-testing and met. office; part owner and operator of three properties. 1905–08, Studied min. engng., met. and chem. with C. J. Callahan. 1908–10, Opened engng., met., assaying and chem. office in Mazuma. 1910–19, Conducting office and laboratory; perfected flotation machine for handling molybdenite ores producing MOS_2 88 to 90 per cent. with extraction of 90 to 95 per cent. of values. Specialized in oil flotation for eight years.
Present position: Prop., Pacific Ore Testing & Dev. Co.

Moses F. Peltier, Sheridan, Wyo.
Proposed by Herbert Addison, Daniel Harrington, Carl Scholz.
Born 1873, Wilmington, Ill. High School and Correspondence School. 1901–04, Min. Engr., Spring Valley Coal Co.; City Engr., City of Spring Valley, Ill. 1904–16, Chief Engr., Peabody Coal Co.
Present position—1916 to date: Pres., Monarch Coal Min. Co.; Cons. Engr., Peabody Coal Co.

Carlos A. Portella, Cerro de Pasco, Peru.
Proposed by Anterior Rizo Patron, Myron R. Walker, Luis F. Diaz.
Born 1880, Lima, Peru. 1901, Grad., School of Engineers of Lima, M. E. 1902, Engr., Sociedad Miniere Huacracocha. 1902–04, Administrator Sociedad Miniere Sacracancha. 1904–07, Engr., Chief Engr., Official Commission of Morococha. 1907–08, Engr., Sociedad Minera Alapampa. 1908–14, Deputy of Mines and Inspector General of Mines, District of Cerro de Pasco. 1914–17, Traveling through Chile, Bolivia and Argentina for study.
Present position—1917 to date: Chief of Office of Fundicion El Eco.

Atsumaru Sakaguchi, Tochigiken, Japan.
Proposed by Kosaku Asano, Fukunasuke Yamada, Hajime Nakamura.
Born 1886, Tokyo, Japan. 1907–10, First Higher School. 1910–13, Imperial Univ., Tokyo, Japan, degree of Kogakushi. 1913–14, Foreman, No. 5 District, Ashio copper mine. 1914–16, Chief Engr., Honzan mine, Ashio copper mine.
Present position—1916 to date: Supt., Ashio Copper Mine.

Carlos R. Schroth, Cerro de Pasco, Peru.
Proposed by Anterior Rizo Patron, Luis F. Diaz, Myron R. Walker.
Born 1889, Lima, Peru. 1910, Grad., School of Engineers of Lima. 1910–12, Chief Engr., Oficina Metalurgica of Santa Luis y Morococha. 1912–13, Asst. Engr., Cerro de Pasco Min. Co. 1913–15, Engr., Cia. Miniere Rosario y San Lorenzo.
Present position– 1915 to date: Supt., Cia. Miniere La Docena.

John Robert Smith, Jasper, Ala.
Proposed by James Gallacher, H. S. Geismer, Erskine Ramsay.
Born 1883, Lanarkshire, Scotland. 1890–1900, Public Schools, Jefferson Co., Ala. 1905–06, Alabama Polytechnic Inst. 1906–07, Rodman, R. R. Preliminary. 1907, Inspector, sewers and sidewalks, Avondale. 1907–08, Asst. City Engr., North Birmingham, Ala. 1908–17, Contr. Civ. and Min. Engr., Jasper, Ala. 1917, Inspector of Mines, Engrg. Dept., Cons. Coal Co., Jenkins, Ky. 1917–18, Div. Engr., Sloss Sheffield Steel & Iron Co., Birmingham, Ala.
Present position: Asst. State Mine Inspector.

John Theodore Smoody, Brier Hill, Pa.
Proposed by Robert H. Seip, Harrison Souder, Charles Mentzel.
Born 1890, Schenectady, N. Y. 1906, Uniontown High School, Uniontown, Pa. 1910, International Correspondence School. 1914, Alexander Hamilton Inst. 1914, Special study, Columbia Univ. 1910–12, Asst. to Supt., and Chg. of Supplies, Brier Hill Coke Co., Brier Hill, Pa. 1912–13, Draftsman, Westinghouse Electric & Mfg.

Co. 1913–14, Experimental Draftsman, U. S. Bureau of Mines, Pittsburgh, Pa. 1914–15, Designing Engr., American Thread Co. 1915–16, Designing Engr., Chile Copper Co., New York, N. Y. 1916–17, Designing Engr. in chg., Cornwall Ore Bank Co., Cornwall, Pa.

Present position—1917 to date: 2d Lieut., Field Artillery, U. S. Army.

Eugene Stebinger, Washington, D. C.

Proposed by George Otis Smith, M. R. Campbell, David White.

Born 1883, Portland, Ore. 1902–05, Univ. of California. 1906–07, Grad., Univ. of Chicago, B. S. 1907–09, Geologic Aid and Junior Geol., U. S. Geological Survey, Washington, D. C. 1910, Instructor in Geol., Normal College, New York, N. Y. 1910–18, Asst. Geol. and Assoc. Geol., Geol., U. S. Geological Survey, Washington, D. C.

Present position: Geol., U. S. Geological Survey.

Haakon Styri, Pittsburgh, Pa.

Proposed by Fred Crabtree, Charles R. Fettke, Joseph W. Richards.

Born 1886, Kristiania, Norway. 1891–1903, Private Schools, Kristiania. 1903–04, Military Academy. 1904–09, Kristiania Tech. School. 1909–10, Carnegie Inst. of Technology. 1910–11, Royal Polytechnic Academy, Aachen, M. E. Ch. E. Dr. of Eng. 1910–11, Interpreter, International Patent Bureau, Norway. 1911, Chem., Notodden saltpeter works, Norway. 1912–16, Docent of Metallurgy of Iron, Polytechnic Acad., Norway. 1917,' Met.; 1917–18, Cons. Met., Hussey-Binns Steel Co., Charleroi, Pa.

Present position—1917 to date: Asst. Prof. of Met., Carnegie Institute of Technology.

Carroll Harvey Wegemann, Casper, Wyo.

Proposed by W. D. Waltman, Charles T. Lupton, Max W. Ball.

Born 1879, Lake Mills, Wis. 1898–1901, Beloit College Academy. 1901–03, Univ. of Wisconsin, B. S. 1903–05, Post-Graduate work, Univ. of Wisconsin, M. A. 1906–07, Asst. in Geol., Univ. of Illinois. 1907–17, Geol., U. S. Geological Survey.

Present position—1917 to date: Geol., Franco-Wyoming Oil Co.

Joe T. Terry, Silverton, Colo.

Proposed by A. P. Anderson, W. G. Sharp, Sidney J. Jennings, C. F. Moore.

Born 1873, Canon City, Colo. High School, Canon City. Owner and manager, Sunny Side mines, for past 20 years; and other properties, San Juan and Clear Creek Counties, Colo.

Present position: Cons. Min. Engr., Sunny Side M. & M. Co.

Audley Oscar Williams, Niagara Falls, Ont.

Proposed by A. L. McRae, M. H. Thornberry, E. List.

Born 1890, Pidcock, Pa. 1908–12, Georgia School of Technology. 1912–13, Designing and installing mechanical equipment, American Cyanamid Co., Niagara Falls, Ont. 1914–18, Supt., Calcium Carbide Furnace Dept., American Cyanamid Co.

Present position—1918 to date: Chief of Carbide Furnace Division, Air Nitrate Corp., Muscle Shoals, Ala.

Associates

Harold Lattimore Alling, Albany, N. Y.

Proposed by David H. Newland, Charles P. Berkey, James F. Kemp.

Born 1888, Rochester, N. Y. 1910–15, Univ. of Rochester, B. S. 1915–18, Columbia Univ., A. M. 1915, '16, '17, summers, detail geological mapping, Adirondacks. 1917–18, Investigating graphite deposits, Adirondacks, National Research Council.

Present position: Special Investigator, Dept. of Economic Geology, N. Y. State Survey.

Frederick Potter Flagg, Waltham, Mass.

Proposed by Alfred C. Lane, Frank W. Durkee, R. F. Harrington.

Born 1894, Waltham, Mass. 1912–16, Tufts College, B. S. in Chem. 1915–16, Instructor in Chem., in pre-medical course, Tufts College. 1916, Chief Chem., charge of laboratory employing two chemists, Waltham Watch Co.

Present position: Chief Chem., Waltham Watch Co.

Ejuro Kaneko, Tochigiken, Japan.
Proposed by Kosaku Asano, Fukunusuke Yamada, Hajime Nakamura.
Born 1891, Morioka, Japan. 1916, Grad., The Imperial Univ., Tokyo, Japan, degree of Kogakushi. 1916–17, Min. Engr., Ashio copper mine. 1917–18, Development Engr., Honzan mine, Ashio copper mine.
Present position: Foreman, Ashia Copper Mine.

Edmund James Lowry, Pawtucket, R. I.
Proposed by Herbert M. Boylston, F. C. Langenberg, Charles H. White.
Born 1894, Pawtucket, R. I. 1913, Grad., Pawtucket High School. 1917, Grad., U. S. Naval Academy. 1918, Special course, M. I. T. 1915–16, Asst. Foreman, hardening room, Remington U. M. C., Bridgeport, Conn. 1916–17, Foreman, hardening room, Maxim Munitions Corpn., New Haven, Conn. 1917, Foreman, Foundry, Watertown Arsenal, Watertown, Mass. 1917–19, Chief Met., U. S. Cartridge Co., Lowell, Mass.
Present position: Met., Oliver Chill Plow, South Bend, Ind.

Carleton Wight Reade, Escanaba, Mich.
Proposed by C. E. McQuigg, Joseph Struthers, E. D. Campbell.
Born 1895, Escanaba, Mich. 1908–12, Escanaba High School. 1912–13, Lawrence College, Appleton, Wis. 1913–17, Univ. of Michigan, B. S., Ch. E. 1917–18, Engr. of Tests, U. S. Government Metallurgical Section of Inspection Division stationed at Bartlett Hayward Co., Baltimore, Md.; Metal Products Co., Beaver, Pa.; Roberts Engineering Co., Philadelphia, Pa.; Erie Malleable Iron Co., Erie, Pa.; and American Brake Shoe & Foundry Co., Erie, Pa.
Present position—1918 to date: Assist. Supervising Engr. of Tests, Bridgeport District, Ordnance Office.

Eugene Ralph Smoley, Palmerton, Pa.
Proposed by Walter S. Brown, L. S. Holstein, L. A. Wilson.
Born 1898, Cleveland, O. 1915–16, Cornell Univ. 1916–18, Grad., Mass. Institute of Technology, B. S. 1915, Asst. Chem., Scranton Chem. Co. 1916, Summer, drafting, Anthracite Bridge Co., Scranton, Pa.; Asst. on engrg. corps, Pennsylvania R. R. Co. 1917, Summer, Chem., Testing Dept. 1918, Fall, Chem. Engr., Testing Dept., N. J. Zinc Co.
Present position: Investigation work, Zinc Oxide Dept., N. J. Zinc Co.

Irvine Emerson Stewart, Breckinridge, Tex.
Proposed by Arthur F. Truex, J. M. Herald, R. A. Conkling.
Born 1893, Dalkeith, Ontario, Can. 1910–15, McMaster Univ., Toronto, Can. 1915–17, Univ. of Chicago, Chicago, Ill. 1914, B. A. 1915, M. A. 1914–16, Summers, Asst. Geol., Geological Survey of Canada, Ottawa, Empire Gas and Fuel Co., Bartlesville, Okla.
Present position: Geol., Roxana Petroleum Co. of Oklahoma, Tulsa, Okla.

Naoichi Tsuji, Kagoshimaken, Japan.
Proposed by Kosaku Asano, Fukunosuke Yamada, Hajime Nakamura.
Born 1892, Tokyo, Japan. 1911–14, 8th Higher School. 1914–17, Imperial Univ., Tokyo, degree of Kogakushi. 1917–18, Min. Engr., Ashio copper mine.
Present position: Chief Constructing Engr., of Oshima Mine, Furukawa Min. Co.

Charles Joseph Walker, St. Louis, Mo.
Proposed by James A. Caselton, H. A. Wheeler, Arthur Thacher.
Born 1883, Wentzville, Mo. 1900–06, Univ. of Missouri, A. B. 1906–10, General law practice, Everett, Wash. 1910–13, Investigating min. projects, St. Louis Syndicate. 1913–18, Organized and Pres., Western Development Co., St. Louis, Mo. 1914–18, Sec. and Treas., Down Town Mines Co., Leadville, Colo.
Present position: Pres., Western Development Co. and Sec. and Treas., The Down Town Mines Co.

Leonard Edwin Weisenburg, Sharples, W. Va.
Proposed by Arthur C. Adair, Howard N. Eavenson, H. W. Saunders.
Born 1893, So. Bethlehem, Pa. 1915, Pennsylvania State College, B. S. 1913, Summer, min. corps, H. C. Frick Coal & Coke Co. 1915, Summer, Foreman, annealing furnaces, Bethlehem Steel Wks., So. Bethlehem, Pa. 1915–16, Transitman, chief of party, East River tunnels, Public Service Commission, New York, N. Y. 1916–17, Resident Engr., Kentucky River Power Co.; Draftsman, Crystal Block

Coal & Coke Co.; Central Pocahontas Coal Co.; Tug River Electric Co. 1917-18, Chief Engr., Thomas Coal Co., Iroquois Coal Min. Co. and Crystal Coal & Coke Co. 1918, Asst. Chief Engr., Amherst Coal Co.; Lundale Coal Co.
Present position—1918 to date: Asst. Chief Engr., Boone County Coal Corpn.

Junior Associates

Everett Humphreys Parker, Denver, Colo.
Proposed by Robert Peele, Charles E. Berkey, William Campbell.
Born 1894, Marquette, Mich. 1912–16, Dartmouth College.
Present position: Student, Columbia School of Mines, B. S.

Joseph Lewis Rosemiller, So. Bethlehem, Pa.
Proposed by Howard Eckfeldt, Joseph W. Richards, Henry S. Drinker.
Born 1897, Paris, France. 1910–14, Grad., York Collegiate Inst., York, Pa. 1914–15, Grad., Worcester Acad., Worcester, Mass. 1915, Lehigh Univ., So. Bethlehem, Pa., min. engrg. course. 1916, Summer, Plattsburgh Military Camp. 1917, Summer, Shrapnel Inspector, Bethlehem Steel Co., Bethlehem, Pa. 1918, Yeoman, 2d U. S. Naval Reserve Force. 1918, Summer, Bessemer, and open hearth, Bethlehem Steel Co., Sparrows Point, Md.; Oct., U. S. N. R. F. Camp, Cape May, N. J., 1st Petty Officer, Naval Unit, S. A. T. C.
Present position: Student, Lehigh Univ.

Elias Werchowsky, Bettws-y-Coed, Carnarvon, Wales.
Proposed by William Frecheville, S. T. Truscott, Walter McDermott.
Born 1891, Elisabethgrad, Real Gymnasium of Elisabethgrad. 1910–14, Student, Faculties of Sciences and Engineering, Univ. of Liége, Belgium. 1914–15, Student, Royal School of Mines, London, England. 1915–16, Drawing office, Fraser & Chalmers, Ltd., Erith, Kent, England. 1916–17, Practical work in mining and ore-dressing, Basset Mines, Ltd., Redruth, Cornwall. 1917–18, British War Dept., London, England.
Present position: Asst. Mill Foreman, Aler Llyn Zinc Mines, Ltd., Bettws-y-Coed, N. Wales, U. R. Student, Royal School of Mines, on leave.

Change of Status—Junior Associate to Member

Guy Ernest Ingersoll, Minneapolis, Minn.
Proposed by W. H. Emmons, E. H. Comstocke, W. R. Appleby.
Born 1889, Elk River, Minn. 1914–18, Univ. of Minnesota, E. M. 1910–12, Engr. Helper, Rogers Brown Iron Co., Hibbing, Minn. 1912–13, Amalgamator Helper, Liberty Bell Gold Min. Co., Telluride, Colo. 1913–14, Engr., South American Dev. Co., Guayaquil, Ecuador. 1915, Getting efficiency data, Leetonia mine, Hibbing, Minn. 1916 and 17, Summers, Engr., Pickands Mather & Co., Hibbing, Minn. 1917–18, Research Asst., Dept. of Geology, Minnesota School of Mines, Minneapolis, Minn.
Present position: Asst. Metal Min. Engr., U. S. Bureau of Mines.

At the end of 1916 there were 38,000 producing gas wells and 13,000-000 acres of land under the control of gas-producing companies; companies distributed 753,000,000 cu. ft. of gas.

As 1 gal. of raw gas gasoline to 1½ gal. of heavy distillates is an average blend, for motor fuel the 217,000,000 gal. of raw gasoline produced in 1917 was expanded to not less than 500,000,000 gal. of serviceable motor fuel, enough to provide over 100 gal. for each of the 4,810,917 cars registered that year. In 1911, the 176 compression plants making natural-gas gasoline produced 7,425,839 gallons of raw gasoline; in 1916, 596 compression and absorption plants in twelve States, produced 103,492,689 gal., and, in 1917, 886 plants produced 217,884,104 gal.

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Grade	General Requirement	Age (Minimum)	Length of Active Practice	Responsible Charge of Work
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Associate...	Any one interested in mining, geology, metallurgy, or chemistry.			
Junior Associate..	Engineering student who has not received technical degree.			

* See requirements for membership on reverse page.

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REQUIREMENTS FOR MEMBERSHIP

Extract From Constitution

ARTICLE II

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c. 1. The membership of the Institute shall comprise four classes, namely: S mbers; 2. Honorary Members; 3. Associates; 4. Junior Associates.

. members shall be equally entitled to the privileges of membership, excepting Honorary Members, Junior Associates, and Members and Associates whose L ices shall be outside of the United States, Mexico, and Canada, shall not be d to vote. Members and Associates residing within the United States of P ca, Mexico, and Canada, and not in arrears for dues, shall be entitled to vote in at the meetings of the Institute, or, as hereinafter provided for, by letter

C c. 2. MEMBERS shall comprise all those persons who on the third Monday ruary, 1918, were members of the Institute, and in addition thereto, all those fter elected or transferred into the class of Members.

EMBERS must be at least 27 years of age and must have had at least six years' G yment in the practice of engineering, mining, geology, metallurgy or chemistry, ; at least three years of which they must have held positions of responsibility in more of these fields.

B aduation from the scientific course of a college, approved by the Committee on ership, shall be considered equivalent to two years' employment, as required previous sentence.

nployment as a teacher of engineering, mining, geology, metallurgy or chemistry, K irect charge, may be considered a position of responsibility as specified in the J preceding paragraph.

C rsons employed in research or any scientific literary work or in teaching in the M fic departments of colleges, approved by the Committee on Membership, who H same time are engaged in consulting or in the active practice of mining, geology, tallurgy, shall be entitled to consider the time so spent in active practice as R lent to an equal length of time of employment in positions of responsibility, ed the work done or the positions held seem to the Committee on Membership rant the equivalency.

G e requirement of three years' employment in positions of responsibility may be E d by the Committee on Membership in the case of persons who have done notable al work in mining, geology, or metallurgy, or have won distinction by research or C gations in one or more of these subjects. By investigation or research is T tood laboratory experimentation as distinct from investigations in literature B pilations of the work of others.

J SOCIATES shall be those who, in the opinion of the Committee on Membership A e Board of Directors, are suitable for such election or transfer by reason of their H t in or connection with mining, geology, metallurgy, or chemistry.

J NIOR ASSOCIATES shall comprise all students in good standing in engineer- V hools, who have not taken their degrees and are nominated by at least three F ers, two of whom must be their instructors. A Junior Associate may remain ot longer than five years after leaving the engineering school, at the end of H period his qualifications to become a Member or Associate must be passed C by the Committee on Membership. If elected he shall pay at that time the S ce fee and dues of a Member or Associate.

A case there is any question as to the classification of a candidate the Committee embership may require from him any evidence he desires to present and the n of the Committee as to the proper status shall be final.

ery candidate for election as a Member, Associate, or Junior Associate must be ed for election by at least three Members or Associates, must be approved by ommittee on Membership, as prescribed in the By-Laws, and must be elected Board of Directors

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York Meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Fine Crushing in Ball-mills

BY E. W. DAVIS,* MINNEAPOLIS, MINN

(New York Meeting, February, 1919)

Contents

I. OPERATING TESTS

1. Character of Ore under Investigation

On the eastern end of the Mesabi Range, in Northern Minnesota, is a large formation of siliceous rock which contains bands and fine grains of magnetite. The magnetite comprises about 35 per cent. of the rock,

* Supt., School of Mines Experiment Station, University of Minnesota.

the remainder being chiefly quartzite and iron silicates. The rock has a specific gravity of 3.4, a hardness of 7, and is extremely tough.

This large deposit was located early in the history of the Minnesota iron-ore industry but has not been utilized because of its low percentage of iron as compared with the other Mesabi ores, and because of the difficulty and expense of any milling treatment that would concentrate the iron. An investigation, begun about 3 years ago, shows that the magnetite is finely disseminated throughout the entire formation and that there are bands or lenses of higher- and of lower-grade material, in which the magnetite and silicate are intimately mixed. As a result, the scheme of milling adopted must include a fine-crushing plant. As it is necessary to crush to 200 mesh in order to produce the desired grade of product, the fine crushing is one of the largest items of expense and for this reason has been given detailed study. It is the purpose of this paper to present some of the results of the work on fine crushing, as to both theory and practice.

Previous to fine crushing the part of the rock that contains little or no magnetite can be discarded by magnetic concentrators after each reduction in size in the dry-crushing plant. This makes it possible to fine-crush a minimum of rock and also establishes the feed to the ball-mill as below ¼ in. The fine-crushing problem, then, consists simply in crushing the rock from ¼ in. to 200 mesh at the minimum expense.

2. Equipment of the Testing Plant

In order to determine, among other things, the operating conditions of the ball-mill when working on this rock, a test mill of about 300 T. daily capacity was erected at Duluth, Minn. The fine-crushing plant contains a Hardinge 8-ft. by 22-in. (2.4-m. by 55.8-cm.) conical mill, a 6- by 27-ft. (1.8 by 8.2-m.) Dorr duplex bowl-type classifier, a 4½-ft. (1.37-m.) standard Akins classifier, and the auxiliary machinery necessary to handle the products. Each machine is driven by an individual motor, each of which is provided with meters for measuring the power required. Over 150 tests have been made in the ball-mill, varying in duration from a few hours to several weeks, in every case being continued until operating conditions became steady. The plant is so constructed that good samples of all products can be secured, both by automatic samplers and by hand. An apron feeder governs the feed rate and the tonnage is checked in every test. Water is metered into the circuit and every precaution is taken to make the data accurate and reliable.

It is a little hard to secure a basis upon which to compare crushing results. Neither Kick's nor Rittinger's law of crushing is of much use in this case. This is evident when it is considered that the average size of a particle finer than 200 mesh is a matter of opinion, and that in

this crushing problem practically all the ore must be crushed to pass a 200-mesh screen. The comparisons have therefore been made on the basis of kilowatt-hours per ton of material finer than 200 mesh actually produced. This, of course, does not give a scientifically exact basis for comparison, but since only the material below 200 mesh is considered finished product, in this case this is a suitable method for comparison.

3. Open-circuit Crushing

The object of this test was to determine the crushing efficiency of the ball-mill when operating in open circuit. The conditions were as follows:

Feed rate, variable from 3 to 18 T. per hr.
Ball load, 28,000 lb. of 5-, 4-, 3-, and 2½-in. balls.
Speed, 19.7 r.p.m.
Ball-mill power, 88 kw.
Feed, minus ¼ in., containing 6.52 per cent. minus 200-mesh material.
Amount of solids, about 50 per cent.

Table 1.—*Data Obtained in Open-circuit Crushing*

	Test No.				
	1	2	3	4	5
Feed, tons per hour	3.66	7.40	11.00	15.00	18.00
Tons of −200 mesh actually produced per hour	2.24	3.77	4.85	6.03	7.67
Kilowatt-hours per ton of −200 mesh produced	38.55	23.53	18.04	14.62	11.55

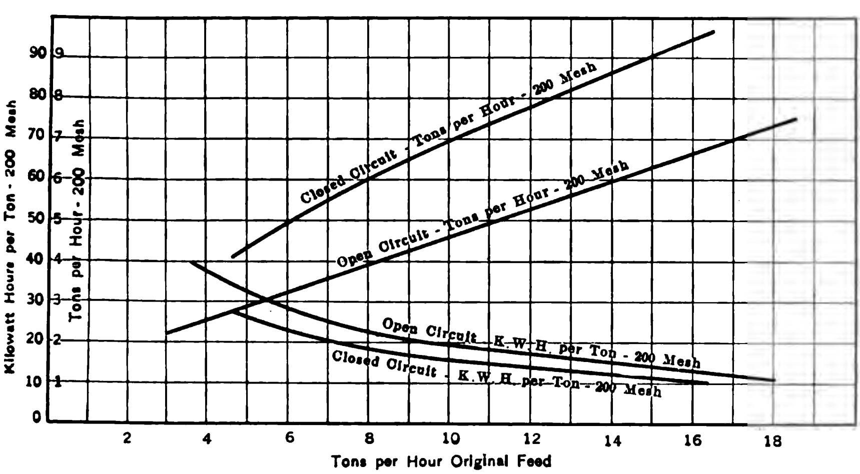

Fig. 1.—Comparison of open and closed circuit crushing.

Fig. 1 shows graphically that the tonnage of minus 200-mesh material produced varies directly with the tonnage fed to the mill. There is undoubtedly some limit to this relation, but there seems to be no indication of it at 18 T. per hr. Some of the conclusions drawn from this test are that: (*a*) The ball-mill is naturally a machine of very large capacity; (*b*) if it is not possible to deliver a large tonnage of original feed to the mill, a closed circuit should be provided so that the mill may crush its own oversize.

4. Closed-circuit Crushing

The object of these tests was to determine the crushing efficiency of the ball-mill when crushing in closed circuit with a classifier. The conditions were as follows:

Feed rate, variable from 4 to 15 T. per hr.
Ball load, 28,000 lb. of 3- and 2-in. balls.
Speed, 23.8 r.p.m.
Ball-mill power, 108 kw.
Feed, minus ¼-in. material.
Amount of solids, about 60 per cent.

Table 2.—*Data Obtained in Closed-circuit Crushing*

	Test No.							
	108	110	111	112	113	149	150	154
Feed, tons per hour	4.63	5.00	5.50	6.50	7.37	11.00	12.57	15.31
Tons per hour of −200 mesh actually produced	4.01	4.34	4.62	5.34	5.63	6.82	8.07	9.11
Kilowatt-hours per ton of −200 mesh produced	26.95	24.90	23.40	20.20	19.20	16.00	13.10	11.92

The results of these tests also are shown in Fig. 1. It is interesting to note that the curve showing tons per hour of minus 200-mesh material does not tend to flatten out as the tonnage to the mill is increased. The power per ton is also continually decreasing. It is, of course, impossible to state how much further this condition will continue, but it seems evident that it will continue for tonnages considerably beyond 15 T. per hr. As the two curves are slowly converging, at some large tonnage the amount of minus 200-mesh material produced per kilowatt-hour will be the same for either open- or closed-circuit crushing. The real advantage then gained by the closed-circuit system lies in the fact that the product consists of particles much more uniform in size. Although the average reduction in both systems may be the same, the closed-circuit will deliver a product in which the maximum-size particle will be much nearer the average size than will the open-circuit system.

The following conclusions may be stated from these two series of tests: (a) For equal tonnages of original feed, the closed-circuit crushing system produces the greater tonnage of minus 200-mesh material per kilowatt-hour. (b) For equal tonnages of original feed, the closed-circuit system of crushing shows the greater average reduction. (c) There is no indication that the mill was operated at, or even near, a tonnage that would give the greatest number of tons of minus 200-mesh material per kilowatt-hour. (d) Closed-circuit crushing will always have the advantage over open-circuit crushing, in that the maximum-size particle produced will be much nearer the average size. This is a desirable condition since the size of the balls making up the charge must be computed on the maximum-size particles in the feed rather than the average size.

5. Single-stage Crushing No. 113

The object of this test was to determine the capacity of the ball-mill crushing in closed circuit and producing 200-mesh material. The conditions were as follows:

Feed rate, 7.37 T. per hr.
Classifier, Dorr duplex bowl-type.
Ball load, 28,000 lb. of 2- and 2⅜-in. balls.
Speed, 23.8 r.p.m.
Ball-mill power, 108 kw.
Feed, minus ¼-in. ore.
Amount of solids, about 70 per cent.

Table 3.—*Data Obtainde in Single-stage Crushing*

Mesh*	Opening, Mm.	Ball-mill Feed		Classifier Overflow	
		Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.
On 4	4.70	29.18	29.18		
On 8	2.36	27.07	56.25		
On 14	1.17	15.41	71.66		
On 28	0.59	7.93	79.59		
On 48	0.295	4.51	84.10		
On 100	0.147	3.66	87.76	1.45	1.45
On 200	0.074	2.85	90.61	11.75	13.20
On 300		1.61	92.22	14.95	28.15
Through 300		7.78	100.00	71.85	100.00
		100.00		100.00	

*Tyler standard testing screens were used throughout this investigation.

There were 5.63 T. of minus 200-mesh material actually produced per hour and 19.2 kw.-hr. per ton of minus 200-mesh material produced were required. The classifier delivered 33 T. of sand per hour. The total ball-mill feed was therefore 40.37 T. per hr. or 550 per cent. of the original feed.

6. Two-stage Crushing

The object of these tests was to determine the capacity of ball-mills when crushing in two stages. The conditions of the test were as follows:

First Stage

Feed rate, 15.31 T. per hr.
Classifier, Dorr duplex with baffled overflow.
Ball load, 28,000 lb. of 3- and 2-in. balls.
Speed, 23.8 r.p.m.
Ball-mill power, 108 kw.

Second Stage

Feed rate, 6.54 T. per hr.
Classifier, Dorr duplex.
Ball load, 28,000 lb. of 2- and 1-in. balls.
Speed, 23.8 r.p.m.
Ball-mill power, 108 kw.

Table 4.—*Data Obtained in Two-stage Crushing*

Mesh	Opening, Mm.	First Stage				Second Stage			
		Ball-mill Feed		Classifier Overflow		Ball-mill Feed		Classifier Overflow	
		Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.
On 4	4.70	29.17	29.17						
On 8	2.36	26.22	55.39						
On 14	1.17	14.13	69.52			0.30	0.30		
On 28	0.59	8.62	78.14			0.32	0.62		
On 48	0.295	4.67	82.81	4.30	4.30	5.40	6.02		
On 100	0.147	3.32	86.13	15.80	20.10	39.00	45.02	2.45	2.45
On 200	0.074	3.28	89.41	18.80	38.90	37.98	83.00	13.25	15.70
On 300		1.68	91.09	11.35	50.25	8.24	91.24	17.70	33.40
Through 300		8.91	100.00	49.75	100.00	8.76	100.00	66.60	100.00
		100.00		100.00		100.00		100.00	

In the first stage, 9.11 T. of minus 200-mesh material were produced per hour and 11.98 kw.-hr. were required for each ton of minus 200-mesh material produced. The classifier delivered 32 T. of sand per hour. The total feed to the mill was therefore 47.31 T. per hr. or 308 per cent. of the original feed. The classifier overflow was reclassified, most of the material below 200 mesh being discharged from the crushing circuit while the sands were fed to the second stage. In this stage 3.73 T. of minus 200-mesh material were produced per hour and 28.9 kw.-hr. were required for each ton of minus 200-mesh material produced.

The classifier delivered 5 T. of sand per hour. The total feed to the ball-mill was therefore 11.54 T. per hr. or 179 per cent. of the

original feed. It was evident that the ball-mill was greatly underloaded in this test, but so much trouble developed in the classifier, due to the tendency of the sands to slip down the slopes, that a more rapid feed was not attempted at this time. The classifier had been set at a slope of 1½ in. per ft. (125 mm. per m.) and conditions were such that the slope could not be decreased. It was impossible also to use the bowl overflow at this flat slope without rebuilding the classifier. At the present writing this work has not been completed. It seems certain, however, that the ball-mill will crush to 200 mesh a considerably greater tonnage when the proper classification is provided. Since in previous tests the mill has crushed 7½ T. per hr. from ¼ in. to 200 mesh, it seems possible that it will crush at least 8 T. per hr. from 48 to 200 mesh.

Comparing single- and double-stage crushing on the basis of these two tests, it appears that the single-stage crushing produces a ton of minus 200-mesh material for 19.2 kw.-hr. while double-stage crushing produces a ton of minus 200-mesh material for 16.8 kw.-hr. These figures, though, do not show the real relative efficiencies of the two systems, for the second stage of the two-stage system was so obviously underloaded. The conclusions drawn from these tests are that (*a*) two-stage crushing shows a greater efficiency than single-stage, (*b*) two-stage crushing is much more flexible and offers greater possibilities for improvement than does single stage. In addition, a considerable amount of tailing can be discarded between the stages.

7. Large vs. Small Balls

Two tests with closed-circuit crushing are reported to show the efficiency of the ball-mill when charged with large and with small balls.

Test No. 12 shows a production of 6.3 T. of minus 200-mesh material per hour, which is 17.15 kw.-hr. per ton of this material actually produced. Test No. 150 shows a production of 8.07 T. of minus 200-mesh material per hour, which is 13.10 kw.-hr. per ton of this material actually produced. These two tests clearly indicate the superiority of small balls. It is instructive to compare the classifier sands in these two tests (see Table 6).

It appears that the small balls produced a much more uniform sand than did the large balls. The evident crowding of material at certain sizes is almost entirely absent in the small-ball test. Since this classifier sand is composed of the particles of ore that have passed through the mill at least once without being crushed, it appears that the large balls

TABLE 5.—*Data Obtained in Closed-circuit Crushing with Large and Small Balls*

Operating Factors	Test No. 12, Large Balls	Test No. 150, Small Balls
Feed rate, tons per hr.	10.8	12.57
Classifier	Drag type	Dorr duplex
Ball load, lb.	28,000	28,000
Size of balls, in.	5, 4, 3, 2½	2⅜, 2
Max. size of feed, in.	¼	¼
Speed, r.p.m.	23.8	23.8
Ball-mill power, kw.	109	108
Per cent. solids in feed	60	60
Circulating load, tons per hr.	40	27

Mesh	Opening, Mm.	Test 12, Large Balls				Test 150, Small Balls			
		Ball-mill Feed		Classifier Overflow		Ball-mill Feed		Classifier Overflow	
		Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.
On 4	4.70	22.70	22.70			47.80	47.80		
On 8	2.36	31.98	54.68			19.08	66.88		
On 14	1.17	14.64	69.32			10.19	77.07		
On 28	0.59	6.60	75.92			6.03	83.10		
On 48	0.295	6.55	82.47			3.32	86.42		
On 100	0.147	4.13	86.60	11.50	11.50	2.64	89.06	8.65	8.65
On 200	0.074	3.90	90.50	20.80	32.30	2.41	91.47	18.70	27.35
On 300		1.07	91.57	10.85	43.15	1.50	92.97	12.80	40.15
Through 300		8.43	100.00	56.85	100.00	7.03	100.00	59.85	100.00
		100.00		100.00		100.00		100.00	

TABLE 6.—*Classifier Sands in Tests of Table 5*

Mesh	Opening, Mm.	From Large Balls		From Small Balls	
		Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.
On 4	4.70			10.26	10.26
On 8	2.36	0.74	0.74	9.64	19.90
On 14	1.17	2.80	3.54	9.86	29.76
On 28	0.59	12.50	16.04	14.38	44.14
On 48	0.295	31.60	47.64	18.10	62.24
On 100	0.147	36.60	84.24	19.78	82.02
On 200	0.074	7.48	91.72	10.08	92.10
On 300		4.20	95.92	2.36	94.46
Through 300		4.08	100.00	5.54	100.00
		100.00		100.00	

reduce the coarse particles very readily but have trouble in crushing the finer particles. On the other hand, the small balls appear to crush all particles equally well. From this it would seem to be possible, by an analysis of the classifier sands, to determine whether or not the balls are too large or too small for the work they are doing. If the screen analysis of the sands is crowded on the upper end, the balls are too small; if it is crowded at the approximate size of the overflow, the balls are too large. The best results have been obtained when the screen analysis of the sands is about uniform between the size of the original feed and the size of the overflow.

8. Relation Between Speed of Mill and Size of Balls

Improper mill speed seems to be indicated in the same way. Table 7 shows screen analyses of classifier sands from tests in which only the speed of the mill was changed.

Table 7.—*Classifier Sands from Balls of 5-, 4-, 3-, and 2½- in. Diameter*

Mesh	Opening, Mm.	16.6 r.p.m.		19.7 r.p.m.		23.8 r.p.m.	
		Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.
On 4	4.70	3.78	3.78				
On 8	2.36	6.32	10.10	1.02	1.02		
On 14	1.17	5.56	15.66	4.30	5.32	3.54	3.54
On 28	0.59	7.35	23.01	15.34	20.66	12.50	16.04
On 48	0.295	14.71	37.72	30.43	51.09	31.60	47.64
On 100	0.147	35.41	73.13	33.24	84.33	36.60	84.24
On 200	0.074	20.16	93.29	10.08	94.41	7.48	91.72
On 300		2.51	95.80	1.38	95.79	4.20	95.92
Through 300		4.20	100.00	4.21	100.00	4.08	100.00
		100.00		100.00		100.00	

The balls were so much too large that a reduction in speed to 16.6 r.p.m. could not compensate for them. In the next tests the balls were more nearly of the proper diameter for the work to be done.

TABLE 8.—*Classifier Sands from Balls of 4-, 3-, 2½, and 2-in. Diameter*

Mesh	Opening, Mm.	19.8 r.p.m.		21.1 r.p.m.		23.8 r.p.m.	
		Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.
On 4	4.70	1.84	1.84	1.46	1.46		
On 8	2.36	1.32	3.16	0.82	2.28	0.66	0.66
On 14	1.17	1.86	5.02	1.14	3.42	1.34	2.00
On 28	0.59	4.26	9.28	3.28	6.70	4.19	6.19
On 48	0.295	9.20	18.48	8.82	15.52	9.65	15.84
On 100	0.147	25.84	44.32	26.06	41.58	29.44	45.28
On 200	0.074	34.86	79.18	35.64	77.22	36.22	81.50
On 300		11.88	91.06	11.46	88.68	10.98	92.48
Through 300		8.94	100.00	11.32	100.00	7.52	100.00
		100.00		100.00		100.00	

In the tests shown in Table 9, in which balls of 2½-, 2-, and 1½-in. diameter (63.5, 50.8, and 38.1 mm.) were used, the tonnage also being increased, the effect of a change in speed is much more marked.

TABLE 9.—*Classifier Sands from Balls of 2½-, 2-, and 1½-in. Diameter*

Mesh	Opening, Mm.	19.8 r.p.m.		23.8 r.p.m.	
		Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.
On 4	4.70	34.06	34.06	10.26	10.26
On 8	2.36	14.06	48.12	9.64	19.90
On 14	1.17	9.54	57.66	9.86	29.76
On 28	0.59	10.24	67.90	14.38	44.14
On 44	0.295	10.94	78.84	18.10	62.24
On 100	0.147	11.56	90.40	19.78	82.02
On 200	0.074	6.28	96.68	10.08	92.10
On 300		1.52	98.20	2.36	94.46
Through 300		1.80	100.00	5.54	100.00
		100.00		100.00	

In the preceding test, at 19.8 r.p.m. the circulating load became so large, over 60 T. per hr., that operation had to be discontinued for the mill was unable to handle the coarse ore. The obvious conclusion is that either the speed of the mill should be increased slightly or balls of a little larger diameter should be used. At 23.8 r.p.m. the sands were nearly uniform and at this speed the mill showed the greatest efficiency.

In order to show the marked effect of a slight change in the average size of balls, the two tests shown in Table 10 are reported, in which all conditions were the same except the size of balls.

TABLE 10.—*Effect of Slight Change in Size of Balls*

Mesh	Opening, Mm.	Avg. Size, 2¼ in.		Avg. Size, 2⅝ in.	
		Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.
On 4	4.70	10.26	10.26	0.80	0.80
On 8	2.36	9.64	19.90	3.22	4.02
On 14	1.17	9.86	29.76	7.44	11.46
On 28	0.59	14.38	44.14	18.84	30.30
On 48	0.295	18.10	62.24	31.04	61.34
On 100	0.147	19.78	82.02	25.36	86.70
On 200	0.074	10.08	92.10	7.92	94.62
On 300		2.36	94.46	1.94	96.56
Through 300		5.54	100.00	3.44	100.00
		100.00		100.00	

From this series of tests the following conclusions may be drawn:

(*a*) If the balls are large or the speed of the mill is high, crowding will appear at the finer sizes in the classifier sands.

(*b*) If the balls are small or the speed is low, crowding will appear at the coarser sizes in the classifier sands.

(*c*) The indications are that best efficiency is obtained when the screen analysis of the sands shows a minimum of crowding at any size. This statement has not been proved conclusively, however.

9. Deductions from Operating Tests

The foregoing tests are only a few of the more important ones that were made. Over 150 tests have been made altogether, and it may be of value to state some of the general conclusions from them.

1. In every case an increase in the tonnage fed to the mill resulted in an increase in the efficiency.

2. In every test the limiting factor of the test was not the ball-mill but some auxiliary apparatus, usually the classifier.

3. All tests point to the fact that the ball-mill is a machine of very large capacity, especially if it is provided with proper auxiliary apparatus.

4. Classifying and pulp-handling machines that will handle a circulating load of at least 500 per cent. of the original feed should be provided.

5. Closed-circuit crushing is more desirable than open-circuit.

6. The real advantage in closed-circuit crushing lies in the fact that the maximum size of particle is nearer the average size of particle discharged from the circuit.

7. Two-stage crushing is more efficient than single-stage.

8. The real advantage in two-stage crushing lies in the fact that the ball charges can be adjusted more nearly to the required conditions.

9. Two-stage open-circuit crushing does not present this advantage, as the maximum-sized particle in both stages is more nearly the same.

10. The proper adjustment between size of balls and speed of mill can be secured by an examination of the classifier sands.

11. If the balls are large or the speed is high, the screen analysis of the classifier sands will be crowded at the finer sizes.

12. If the balls are small or the speed is low, the screen analysis of the classifier sands will be crowded at the coarser sizes.

13. From the data at hand, the indications are that the best efficiency is obtained when the screen analysis of the classifier sands shows a minimum of crowding at any size.

14. Balls no larger than necessary should be used, as this makes it possible to charge the mill with the greatest number of balls.

15. Balls smaller than can crush the larger particles of ore should not be kept in the mill as they take up space, absorb power, and do inefficient crushing.

10. Design and Regulation of a Fine-crushing Plant

In view of these conclusions and the test data at hand, it is interesting to outline the manner in which a fine-crushing plant may be designed. In this discussion, the following limitations are imposed:

(*a*) The first cost of the plant must not be excessive.

(*b*) Since the experiments were made with a Hardinge mill and a Dorr classifier, these are given first consideration herein, although not necessarily the best adapted for the work to be done.

(*c*) The plant is to receive a feed and deliver a final product approximately as shown in Table 11.

Table 11.—*Feed and Product of Plant*

Mesh	Opening, Mm.	Feed		Product	
		Per Cent.	Cum. Per Cent.	Per Cent.	Cum. Per Cent.
On 4	4.70	29.17	29.17		
On 8	2.36	26.22	55.39		
On 14	1.17	14.13	69.52		
On 28	0.59	8.62	78.14		
On 48	0.295	4.67	82.81		
On 100	0.147	3.32	86.13	0.50	0.50
On 200	0.074	3.28	89.41	6.65	7.15
On 300		1.68	91.09	13.75	20.90
Through 300		8.91	100.00	79.10	100.00

The flow sheet shown in Fig. 2 has been designed to meet these requirements. Its most conspicuous feature is the large number of classifiers; possibly there are too many, but in all tests the limiting factor has been the capacity of these machines. It is estimated that the capacity of this plant will be 720 T. per day, receiving a feed and delivering a product as shown. The plant will require 344 kw. at the switchboard, which will be 11.5 kw.-hr. per ton of ore crushed, or 14 kw.-hr. per ton of minus 200-mesh material actually produced. This is not an extremely low figure as better results have been obtained many times in the tests.

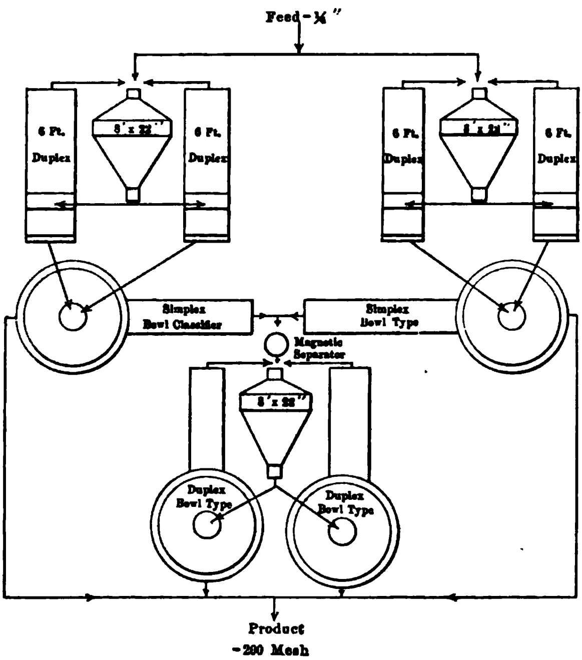

FIG. 2.—FLOW SHEET.

The 720 T. per day, or 30 T. per hr., of original feed will divide to the various units in the following manner: Each first-stage ball-mill will crush 15 T. per hr. to minus 48 mesh. This 15 T. will pass into the Simplex bowl-type classifier, where 10 T. will overflow as finished product; the 5 T. of sand, with the 5 T. of sand from the second Simplex bowl-type classifier, will constitute the feed to the second-stage ball-mill. The test data indicate that this can be accomplished with one classifier in closed circuit with each ball-mill. By adding the second classifier, as shown, it is expected that the tonnage can be increased at least 25 per cent. In order to maintain this feed rate, it will be necessary to maintain carefully the proper ball charge in each mill. A slight increase or

decrease in the average size of the balls making up the charge will cause a large loss in efficiency and a corresponding reduction in tonnage.

If balls 3 in. (76.2 mm.) in diameter are fed to the first-stage mills and if all balls less than 2 in. (50.8 mm.) in diameter are removed from the mills regularly, the average size of the balls forming the working charge will be 2.499 in. (63.47 mm.), which is about the size indicated in the tests as giving the best results. The working ball charge in the mill will be as shown in Table 12.

TABLE 12.—*Working Ball Charge in Mill*

Diameter of Balls, In.	Per Cent. of Weight	Actual Weight, Lb.
3.00 to 2.75	32.63	9,136.4
2.75 to 2.50	27.21	7,618.8
2.50 to 2.25	22.32	6,249.6
2.25 to 2.00	17.84	4,995.2
Total	100.00	28,000.0

Suppose that once every week the mills are stopped and all balls less than 2 in. in diameter are removed. If the ball wear is 2 lb. per ton of ore crushed, this will amount to 720 lb. (326.5 kg.) per day for each mill. This is actual wear and takes no account of the small balls that are removed. Then, since the working charge is to comprise balls from 3 in. (76.2 mm.) to 2 in. (50.8 mm.) in diameter, the amount of wear secured from each ball will be 2.89 lb. (1.31 kg.) and the 720 lb. of wear per day will be taken care of by the reduction in diameter of 249 balls per day from 3 in. to 2 in. It will then be necessary actually to charge 249 three-inch balls, or 1020 lb. (462.6 kg.) per day.

It is evident that some of the minus 2-in. balls that will be removed after seven days will be smaller than others. It may be computed by methods hereinafter described that the smallest ball will be 1.92 in. (48.7 mm.) in diameter. Then if 249 three-inch balls are charged at the beginning of each day, at the end of each day 249 balls will have been worn to a diameter of less than 2 in. At the end of seven days there will be 1743 balls of diameter between 2 and 1.92 in., which will weigh 1995 lb. (904.9 kg.) and will be removed from the mill. As the operation of each of the first-stage mills will consist in charging 249 three-inch balls each day, the mill charge will gain in weight each day until at the end of seven days it will have gained 1995 lb. and will therefore weigh 29,995 lb. At the end of the seven days, however, the 1995 lb. of balls smaller than 2 in. will be removed, leaving the original 28,000 lb. working charge, as at the beginning of the week.

Since in this flow sheet there are two first-stage mills, there will be

formed 3990 lb. (1809.8 kg.) of balls per week of average diameter 1.96 in. (49.7 mm.). These 3990 balls will be used up each week in the daily charges of balls to the second-stage mill. In order to have a balanced condition, it will be necessary to charge these balls at the same rate as that at which they are made, or 498 balls per day. These 498 balls, weighing 571 lb. (259 kg.), will constitute the daily charge to the second-stage mill. This mill is to handle 240 tons of ore per day and the steel consumption at 2 lb. (0.9 kg.) per ton will be 480 lb. (217 kg.) per day. Since 498 balls, weighing 571 lb., are to be added to the mill each day, 498 balls weighing 91 lb. (41 kg.) should be removed each day. These 498 balls will weigh 0.1827 lb. (0.08 kg.) each and will be 1.06 in. (26.9 mm.) in diameter. At regular intervals all balls less than 1 in. in diameter should be removed from the second-stage mill.

It is now possible to compute the screen analysis of the working charge of balls in the second-stage mill (see Table 13).

TABLE 13.—*Screen Analysis of Balls in Second-stage Mill*

Size of Ball, In.	Per Cent. of Weight	Actual Weight, Lb.
1.96 to 1.75	33.23	9,304.4
1.75 to 1.50	30.32	8,489.6
1.50 to 1.25	21.90	6,132.0
1.25 to 1.00	14.55	4,074.0
Total	100.00	28,000.0

If the ball charge in the second-stage mill is screened once a month, there will be 14,940 balls less than 1 in. in diameter to remove. The smallest ball will be 0.85 in. (21.59 mm.) in diameter and the largest ball will be 1 in. The total weight of the balls removed at the end of the month will be 1825 lb. (824.8 kg.). The removal of this weight of small balls will again produce the original charge that is shown in the above screen analysis. Of course, if the ball wear is not 2 lb. per ton, as assumed, these figures will not hold. However, as soon as the correct ball wear is found, it will be possible to determine by this method the exact figures that will make it possible to maintain the proper ball charge and the balance between the different mills at all times. As a result in the design of this fine-crushing plant, provision should be made for sizing the ball charges of the first-stage mills each week and of the second-stage mill each month. It can then be done with a very small amount of lost time.

The chief advantages in this flow sheet are: Good efficiency as to the power expended; large tonnage for the capital invested; and flexibility.

By adjusting the overflow end of the classifier in the first stage, the load can be balanced perfectly between the two crushing stages.

II. MECHANICS OF THE BALL-MILL

In the endeavor to determine the best working conditions for the ball-mill, a detailed mathematical study was made of the action of the ball charge. While the data taken from a properly conducted test are convincing, an engineer sometimes prefers a mathematical proof. Test data contain a large personal factor, not only of manipulation but also of the person reporting the results. In the case of ball-mill crushing the amount of available data is enormous and, by careful selection, nearly any statement can be "proved." For this reason, a consideration which is entirely theoretical and devoid of any personal element would seem to be desirable and instructive.

It is evident that the ball inside a revolving mill must act according to some exact regulating force which governs its every motion. There are three important variables to consider: the speed of the mill, its size, and the size of the ball charge, and it will be the aim of this discussion to show the relation existing between these variables.

11. Action of Charge at Slow Speed

Any loose charge piled up in a cone will assume a certain definite critical angle, usually called the angle of repose. If more of the charge is added to the top of the cone, this will be increased in size but the same critical angle will be maintained. This is what happens inside a mill revolving at very low speeds. The charge is tilted until the critical angle is reached, after which the balls simply roll down the slope to the lower side of the mill. This critical angle is affected but slightly by a change in the speed of the mill, up to a certain point; the increase in speed simply increases the rapidity with which the charge is raised to the top of the incline. In this condition the balls are in contact with one another except as they may bounce in rolling down the slope of the charge; also, the balls must roll down the incline at the same rate, pounds per hour, at which they are raised to the top. Then, with a mill half full of balls, any particular ball will roll down the incline something less than twice per revolution of the mill.

As the speed of the mill is slowly increased, the time required to bring the ball back to the top of the pile is diminished, but the time required by it in rolling down remains practically the same. It would seem then that the whole problem of crushing would resolve itself into getting the balls to the top of the heap fast enough. This would be true if it were not for centrifugal force and inertia. As the speed of the mill is increased these two forces grow very rapidly in importance.

12. Action of Charge at Higher Speeds

Consider the forces acting on a particle p, Fig. 3, in contact with the lining of the mill. The centrifugal force c acts to press it against the lining while w_1, a component of the weight w, acts to pull it away from the lining. Then if α_1 is the angle between the vertical axis and the radius op, $w_1 = w \cos \alpha_1$. It is possible for c to be greater than, equal to, or less than w_1 or $w \cos \alpha_1$, for as α_1 decreases w_1 increases. Then $c - w \cos \alpha_1 = f_1$, and f_1 may be positive, negative or zero. If f_1 is positive the particle will be held against the lining of the mill. As α_1 decreases f_1 decreases and if, when α_1 is zero, f_1 is still positive, it is evident that the particle will maintain its contact with the mill lining throughout a complete revolution.

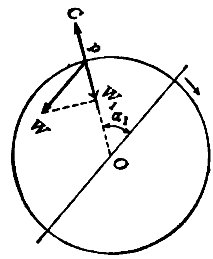

Fig. 3.

If f_1 becomes zero for some value of α_1 the particles below p_1, having a greater angle α, will be held against the lining of the mill by a positive force f. In other words, as the mill rotates, the force with which a particle p is held in position decreases until it reaches zero. At this point the particle is being pushed on by the particles below it and is free to move in a path governed by this initial velocity and gravity. The path it takes will, of course, be parabolic. Then when the angle α is such that f is zero, the particle p will leave off contact with the mill and start on a parabolic path. In this position $c = w \cos \alpha$.

The centrifugal force $c = \frac{wv^2}{rg}$, where w = weight of particle; v = initial velocity; r = radius; and g = 32.2 ft. per sec. per sec. Also the initial velocity of the particle is its velocity in the circular path, or $v = 2\pi rn$ in which n = speed of mill in revolutions per second. Then by substitution in the formula $c = w \cos \alpha$,

$$\frac{wv^2}{rg} = w \cos \alpha, \text{ or } \frac{w(2\pi rn)^2}{rg} = w \cos \alpha, \text{ or}$$

$$\cos \alpha = \frac{4\pi^2 rn^2}{g} \tag{1}$$

From this equation it is evident that an increase in either the speed of the mill or its radius will cause a decrease in the angle α and the parabolic path will not start until the particle is carried farther around in the direction of rotation. At any speed n,

$$\cos \alpha = kr \tag{2}$$

in which $k = 1.226n^2$. Then at constant speed, the particle p nearer the center of the circle than p_1 will start on its parabolic path from a larger angle α, or as r decreases α increases, the relation between r

and α given in equation (2) always holding true when α is the angle at which the parabolic path starts. Equation (2), then, is really the equation of the curve above which all particles are following the parabolic path and below which all particles are following the circular path.

From equation (1) $n = \sqrt{\frac{g \cos \alpha}{4\pi^2 r}}$ and if the radius is considered as the constant, α must decrease as n increases. Since the minimum value of α is zero, when $\cos \alpha = 1$, the speed has reached a point above which c is always greater than $w \cos \alpha$ (Fig. 3), and the particle will cling to the lining of the mill throughout the complete cycle. Then the speed at which any particle of radius r will cling is given by the equation $n = \sqrt{\frac{g}{4\pi^2 r}}$, in which n is in revolutions per second and r is in feet. If the speed is in revolutions per minute the equation will become

$$N^1 = \frac{54.19}{\sqrt{r}} \tag{3}$$

This equation shows the critical speed N^1 at which the particle of radius r will cling to the lining of the mill or to the next outer layer of particles of radius greater than r. If N^1 is sufficiently large, r will be sufficiently small to include all of the balls in the mill and the mill will rotate as a flywheel with no relative motion between the particles in the charge. Table 14 shows the speed at which the first particle will cling to the lining of the mill.

TABLE 14.—*Critical Speeds of Ball-mills*

Diameter of Mill ($2r_1$), Ft.	Critical Speed (N^1), Rev. per Min.	Diameter of Mill ($2r_1$), Ft.	Critical Speed (N^1), Rev. per Min.
0.125	216.76	5	34.27
0.250	153.30	6	31.29
1	76.63	7	28.97
2	54.19	8	27.10
3	44.25	9	25.55
4	38.32	10	24.23

13. PARABOLIC PATHS OF THE FALLING PARTICLES

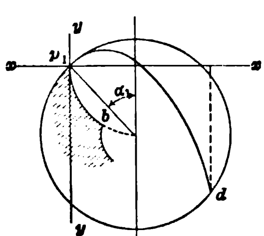

FIG. 4.

Below the critical speed given in equation (3), the particle of radius r will reach the critical angle α and will then start on its parabolic path. The next consideration is to determine where the particle p_1 will strike the lining of the mill at the end of its parabolic path.

In Fig. 4, the equation of the parabola, origin at p_1, is $y = x \tan \alpha_1 - \frac{gx^2}{2V_1^2 \cos^2 \alpha_1}$, and

the equation of the circle of the mill, origin p_1, is $x^2 + y^2 - (2r_1 \sin \alpha_1) x + (2r_1 \cos \alpha_1) y = 0$.

The simultaneous solution of these two equations will give the coördinates of the point d, where the two curves intersect. Substituting the value of y from the equation of the parabola in the equation of the circle and then simplifying, the following equations are secured:

$$\frac{g^2}{4V_1^4 \cos^4 \alpha_1} x^4 - \frac{g \sin \alpha_1}{V_1^2 \cos^3 \alpha_1} x^3 + \left(\sec^2 \alpha - \frac{r_1 g}{V_1^2 \cos \alpha_1}\right) x^2 = 0.$$

Then $x^2 = 0$, and

$$\left(\frac{g^2}{4V_1^2 \cos^2 \alpha_1}\right) x^2 - g \tan \alpha_1 x + V_1^2 - r_1 g \cos \alpha_1 = 0.$$

The initial velocity $V_1 = 2\pi r_1 n$, and $V_1^2 = 4\pi^2 r_1^2 n^2$.

But from equation (1) $n^2 = \frac{g \cos \alpha_1}{4\pi^2 r_1}$; therefore $V_1^2 = r_1 g \cos \alpha_1$. Substituting this value for V_1^2 in the above equation and simplifying,

$$\frac{x^2}{4r_1 \cos^3 \alpha_1} - x \tan \alpha_1 = 0.$$

Then $x = 0$ and

$$x = 4r_1 \sin \alpha_1 \cos^2 \alpha_1 \tag{4}$$

$$y = -4r_1 \sin^2 \alpha_1 \cos \alpha_1 \tag{5}$$

These are the coördinates of the point d, at which the particle p_1 will strike at the end of its parabolic path. From the above solution, it is seen that there are, in general, four points of intersection between the two curves. In this case, however, only one of these intersections requires consideration, the other three being zero. This is a very important fact, for if this condition did not exist the paths of travel of the various particles would cross and recross one another, resulting in a large friction loss above the pulp level in the mill and the performance of little or no crushing.

14. Application to a Definite Problem

It is now possible to draw the outline of the charge in the mill under operating conditions. Consider an 8-ft. mill running at 24 r.p.m. From equation (2), $\cos \alpha = \frac{1.226 \times 24^2 \times r}{3600} = 0.1962r$, which is the equation of a circle of radius $\frac{0.408}{n^2}$. The center is then on the vertical axis $\frac{0.408}{n^2}$ units above the center of the mill. From this the value of α in the Table 15 can be computed:

TABLE 15.—*Data for Computing Values of* α

r	Cos α	α	x
4	0.7848	38° 18′	6.1072
3	0.5886	53° 56′	3.3624
2	0.3924	66° 54′	1.1328
1	0.1962	78° 41′	0.1512
0	0.0000	90°	0.0000

From the values of r and α, the curve aO, Fig. 5, can be drawn, which is the dividing line between the parabolic path and the circular path of the particles. Then by use of equations (4) and (5) it is possible to find any number of points on the curve cd. This may be done more simply by drawing the circle through the point e and then measuring a distance x to a vertical line which will intersect the circle at the desired point f as in Fig. 5. For this purpose, the corresponding values of x are added to the preceding table.

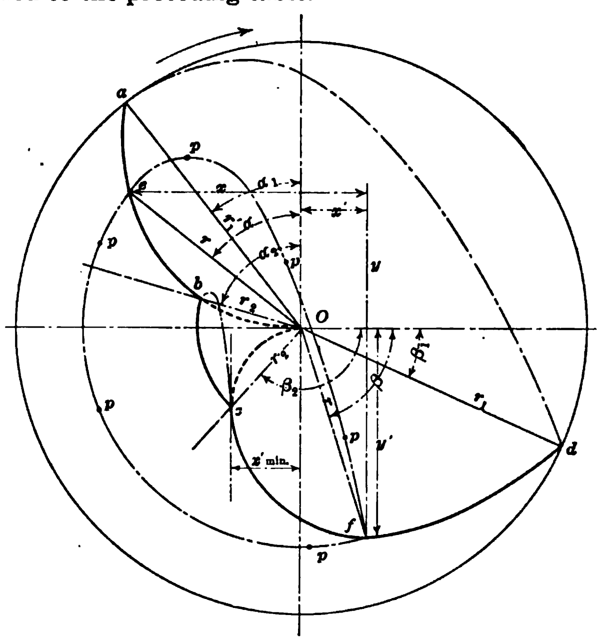

FIG. 5.—PATHS OF TRAVEL OF PARTICLES IN AN 8-FT. MILL MAKING 24 R.P.M.

It is then possible to draw the line Od, which is the dividing line between the parabolic path and the circular path for all particles of the charge. The complete cycle of any particle p is then seen to be from e to f along the parabolic path, and then from f to e along the circular path. From Fig. 5 it is evident that the particle p acts exactly as though it were in a mill of radius r, the lining of which is the layer of particles of radius next larger than r.

15. The End of the Parabolic Path

Since, as has been shown,

$$x = 4r \sin\alpha \cos^2\alpha \text{ and } y = -4r \sin^2\alpha \cos\alpha,$$

from Fig. 5, $x' = 4r \sin\alpha \cos^2\alpha - r\sin\alpha,$

and $y' = 4r \sin^2\alpha \cos\alpha - r\cos\alpha.$

As the value of r at which a particle starts on its parabolic path and ends its parabolic path is the same, then

$$\sin\beta = \frac{y_1}{r} = \frac{4r\sin^2\alpha\cos\alpha - r\cos\alpha}{r} = -(4\cos^3\alpha - 3\cos\alpha).$$

Then $\sin\beta = -\cos 3\alpha$; but $-\cos 3\alpha = \cos(180° - 3\alpha)$ and $\sin\beta = \cos(90° - \beta)$; then $\cos(90° - \beta) = \cos(180° - 3\alpha)$, or $90° - \beta = 180° - 3\alpha$; hence $-\beta = 90° - 3\alpha$,

or
$$\beta = 3\alpha - 90°. \qquad (6)$$

From Fig. 5 it is evident that when α has increased beyond a certain large value, the parabolic paths of the balls near the center of the mill will overlap, thus causing interference. The balls will then be striking together at a point so near the maximum pulp level that little or no effective crushing can be done. It is thus obvious that the size of the charge should be so regulated that this interference shall not occur. It appears from Fig. 5 that this limiting condition occurs when x' is a minimum, or is equal to its largest negative value.

Then since $x' = 4r\sin\alpha\cos^2\alpha - r\sin\alpha$, or eliminating r by use of the equation, $r = \frac{g}{4\pi^2n^2}\cos\alpha$,

$$x' = \frac{g}{\pi^2n^2}(\sin\alpha\cos^3\alpha - \tfrac{1}{4}\sin\alpha\cos\alpha).$$

$$dx' = \frac{g}{\pi^2n^2}(\cos^4\alpha - 3\sin^2\alpha\cos^2\alpha - \tfrac{1}{4}\cos^2\alpha + \tfrac{1}{4}\sin^2\alpha).$$

For maximum and minimum values of x', $dx' = 0$.

Thus $4\cos^4\alpha - \tfrac{7}{2}\cos^2\alpha + \tfrac{1}{4} = 0$;

whence $\cos\alpha = 0.8925$ and 0.2801,

and $\alpha = 26°49'$ and $73°44'$ (7)

From equation (6), $\beta = -9°33'$ and $131°12'$.

The larger result is obviously the one desired, the smaller one being the value that makes x' a maximum. From this it appears that the largest charge that can be used in the mill without definite interference between the particles is when angle $\alpha_2 = 73°44'$ and $\beta_2 = 131°12'$. If the inner radius of the charge, corresponding to $\alpha_2 = 73°44'$, is r_2, then $\cos 73°44' = 1.226n^2r_2$ or $r_2 = \frac{0.2283}{n^2}$, which is the smallest value that r_2 should have at any speed.

16. The Blow Struck by the Falling Particle

In order to determine at what angle α the maximum effective blow will be delivered by the particle when it strikes the surface of the mill, it is necessary to find the resultant velocity of the particle relative to the lining of the mill. Fig. 6 shows the resultant velocities and their components.

V_p = velocity of point on parabola;
V_c = velocity of point on mill;
V_t = component of V_p in direction of V_c, with mill stationary;
V_m = component of V_p in direction of V_c, with mill revolving;
V_r = component of V_p perpendicular to V_c;
θ = angle between V_c and V_p;
V_b = velocity that produces blow; or the velocity of particle relative to lining of mill.

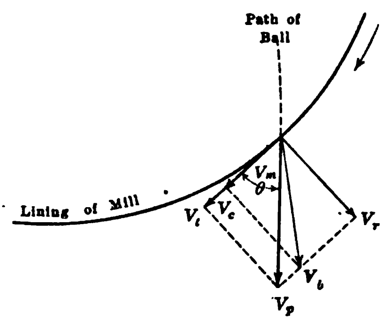

Fig. 6.

It has been shown that the initial velocity of any particle when it started on its parabolic path is given by the equation $V = \sqrt{rg \cos \alpha}$. This is the velocity in the circular path of a particle of radius r. The velocity of any point on the parabola is given by the equation

$$V_p = \sqrt{V^2 \cos^2 \alpha + \left(V \sin \alpha - \frac{gx}{V \cos \alpha}\right)^2}$$

but $V = \sqrt{rg \cos \alpha}$ and $x = 4r \sin \alpha \cos^2 \alpha$.

Then $V_p = \sqrt{9rg \cos \alpha - 8rg \cos^3 \alpha}$.

The velocity of any point on the circle being $V_c = \sqrt{rg \cos \alpha}$,
Then $V_p \cos \theta = V_t$; $V_p \sin \theta = V_r$; $V_t - V_c = V_m$; $\sqrt{V_m^2 + V_r^2} = V_b$.
Then $V_m = V_p \cos \theta - V_c$, and $V_b = \sqrt{(V_p \cos \theta - V_c)^2 + (V_p \sin \theta)^2}$

$$V_b = \sqrt{V_p^2 \cos^2 \theta - 2V_pV_c \cos \theta + V_c^2 + V_p^2 \sin^2 \theta}$$
$$= \sqrt{V_p^2 - 2V_pV_c \cos \theta + V_c^2}$$

$$V_b^2 = 9rg \cos \alpha - 8rg \cos^3 \alpha + rg \cos \alpha - (2\sqrt{9r^2g^2 \cos^2 \alpha - 8r^2g^2 \cos^4 \alpha}) \cos \theta.$$
$$= rg \cos \alpha[10 - 8 \cos^2 \alpha - (2\sqrt{9 - 8 \cos^2 \alpha}) \cos \theta].$$

In order to determine the angle θ it is necessary to find the angle at which the circle and parabola intersect. This is done by computing the slopes of the tangents to both curves at this point and then the angle between these tangents. As the slope of the tangent is the first derivative of the equation of the curve, the slope of the tangent to the circle is

$$\frac{d}{dx}[x^2 + y^2 - (2r \sin \alpha)\, x + (2r \cos \alpha) y] = 0,$$

whence $\dfrac{dy}{dx} = \dfrac{2r \sin \alpha - 2x}{2y + 2r \cos \alpha}$ at the point (x, y).

Then since $x = 4r \sin \alpha \cos^2 \alpha$, and $y = -4r \sin^2 \alpha \cos \alpha$,

$$\frac{dy}{dx} = \frac{4 \sin^3 \alpha - 3 \sin \alpha}{4 \cos^3 \alpha - 3 \cos \alpha},$$

which is the slope of the tangent to the circle.

Likewise for the parabola, the slope of the tangent is

$$\frac{dy}{dx} = \tan \alpha - \frac{2x}{2r \cos^3 \alpha} \text{ at the point } (x, y);$$

then $\dfrac{dy}{dx} = -3 \tan \alpha$ is the slope of the tangent to the parabola.

The angle between two lines is expressed by the equation,

$$\tan \theta = \frac{m_1 - m_2}{1 - m_1 m_2}$$

in which m_1 and m_2 are the slopes.

Then
$$\tan \theta = \frac{-3 \tan \alpha - \dfrac{4 \sin^3 \alpha - 3 \sin \alpha}{4 \cos^3 \alpha - 3 \cos \alpha}}{1 - (3 \tan \alpha) \dfrac{4 \sin^3 \alpha - 3 \sin \alpha}{4 \cos^3 \alpha - 3 \cos \alpha}}$$
$$= \frac{8 \sin^3 \alpha \cos \alpha}{-8 \sin^4 \alpha + 4 \sin^2 \alpha + 1};$$

but
$$\cos \theta = \frac{1}{\sqrt{1 + \tan^2 \theta}};$$

then
$$\cos \theta = \sqrt{\frac{64 \sin^8 \alpha - 64 \sin^6 \alpha + 8 \sin^2 \alpha + 1}{8 \sin^2 \alpha + 1}}.$$

It is now possible to write the complete formula for the effective velocity of the particle:

$$V_b^2 = rg \cos \alpha \left[10 - 8 \cos^2 \alpha - (2\sqrt{9 - 8 \cos^2 \alpha}) \sqrt{\frac{64 \sin^8 \alpha - 64 \sin^6 \alpha + 8 \sin^2 \alpha + 1}{8 \sin^2 \alpha + 1}} \right]$$

This equation may be simplified to $V_b^2 = 16 rg \cos \alpha \sin^4 \alpha$. (8)

But $\cos \alpha = kr$, and $\sin \alpha = \sqrt{1 - k^2 r^2}$.

Then $\sin^2 \alpha = 1 - k^2 r^2$, and $\sin^4 = 1 - 2k^2 r^2 + k^4 r^4$.

and $V_b^2 = 16 kgr^2 - 32 k^3 gr^4 + 16 k^5 gr^6$.

In order to find r for the maximum velocity squared,

$$d(V_b^2) = 32kgr - 128k^3gr^3 + 96k^5gr^5 = 0,$$

or

$$3k^4r^4 - 4k^2r^2 + 1 = 0;$$

Whence $r = \frac{1}{k}$ and $\frac{0.5775}{k}$

When $r = \frac{1}{k}$ When $r = \frac{0.5775}{k}$ (9)

$\cos\alpha = kr$ $\cos\alpha = kr$

$\cos\alpha = \frac{k}{k} = 1$ $\cos\alpha = k\frac{0.5775}{k} = 0.5775$

$\alpha = 0$ for min. V_t^2 $\alpha = 54°44'$ for max. V_b^2 (10)

Thus when $\alpha = 54°44'$ the balls are striking with maximum velocity relative to the circular path in which they travel. Since the whole charge, near ao, may be considered as being concentrated at the radius of gyration, it would seem that the most effective conditions* would be obtained by placing r (equation 9) equal to the radius of gyration of the charge. Since the radius of gyration is equal to $\sqrt{\frac{r_1^2 + r_2^2}{2}}$ when r_1 is the radius of the mill and r_2 is the inner radius of the charge, then

$$\sqrt{\frac{r_1^2 + r_2^2}{2}} = \frac{0.5775}{k} \qquad (11a)$$

But $r_2 = Kr_1$, whence $\sqrt{\frac{(1 + K^2)r_1^2}{2}} = \frac{0.5775}{k}$

But $k = 1.226n^2$, whence $K = \sqrt{\frac{0.443}{r_1^2n^4} - 1}$ (11)

when r is the radius of the mill and n is its speed in rev. per second.

The value of K given by this equation is the relation between r_1 and r_2 which should exist for best operating conditions and is really the measure of the quantity of the charge. This equation then gives the proper relation between the size of the charge, the size of the mill and its speed. It is the fundamental equation of the ball-mill and shows the relations mentioned near the beginning of Section II.

Equation (11) may be restated in the following forms, which may be more convenient.

$$n^4 = \frac{0.443}{(1 + K^2)r_1^2}.$$

Then $n = \frac{0.8158}{\sqrt{r_1}\sqrt[4]{1 + K^2}}$ in rev. per sec., (12)

or $N = \frac{48.948}{\sqrt{r_1}\sqrt[4]{1 + K^2}}$ in rev. per min. (13)

* This is probably not exactly true. Detailed mathematical analysis shows it to be very near the truth, however, and it has been used here for the sake of simplicity.

Since $\cos \alpha = 1.226rn^2$,

$$\cos \alpha = 1.226 \frac{r}{r_1} \sqrt{\frac{0.443}{1 + K^2}} = \frac{0.8165r}{r_1} \cdot \frac{1}{\sqrt{1 + K^2}} \tag{14}$$

in which α is the angle corresponding to any radius r.

Then
$$\cos \alpha_1 = \frac{0.8165}{\sqrt{1 + K^2}} \tag{15}$$

in which α_1 is the angle corresponding to the radius r_1, which is the radius of the mill and is therefore the minimum angle α.

$$\cos \alpha_2 = \frac{0.8165K}{\sqrt{1 + K^2}} = K \cos \alpha_1 \tag{16}$$

in which α_2 is the angle corresponding to the radius r_2, which is the inner radius of the charge and is therefore the maximum angle α.

Equations (12) to (16) all depend on the value of K, which is the real measure of the quantity of the charge. It is now necessary to get a better idea of the exact relation between K and the volume of the charge. In order to do this the cycle of the charge must be known.

17. The Cycle of the Charge

Since $\beta = 3\alpha - 90°$, the angle passed through by a particle in the parabolic path is $\alpha + 90 + \beta$, or $\alpha + 90 + 3\alpha - 90 = 4\alpha$.

If the speed of the mill is n, the time per revolution is $T_r = \frac{1}{n}$. Then the time in the circular path is $T_r \left(\frac{360 - 4\alpha}{360}\right) = T_c$.

The time required by a particle passing through a parabolic curve is given by the equation, $T_p = \frac{x}{V_k \cos \alpha}$.

Then
$$T_p = \frac{2}{\pi n} \sin \alpha \cos \alpha. \tag{17}$$

Again consider the average of the whole charge as passing through the same cycle as the particle at the radius of gyration, which is $\left(\sqrt{\frac{1 + K^2}{2}}\right) r_1$ at the angle $\alpha = 54°44'$. (Equation 10.)

Then
$$T_r = \frac{1}{n}; \quad T_c = \frac{0.392}{n}; \quad T_p = \frac{0.3003}{n}.$$

But the total time of one cycle $T = T_c + T_p = \frac{0.392 + 0.3003}{n} = \frac{0.6923}{n}$

Then the portion of the total time in the circular path is

$$\frac{0.392}{n} \div \frac{0.6923}{n} = 0.5665, \text{ or } 56.65 \text{ per cent. of the time} \tag{18}$$

The number of cycles per revolution is given by the equation,

$$\frac{T_r}{T} = \frac{1}{n} \div \frac{0.6923}{n} = \frac{1}{0.6923} = 1.444 \qquad (19)$$

This means that when the mill is running at the proper speed for the ball charge, then the charge is passing through 1.444 cycles per revolution, and each ball in the charge strikes, on the average, 1.444 blows per revolution.

18. Volume of the Charge

Equation (18) states that the balls spend 56.65 per cent. of the time in the circular path. Then it is apparent that 56.65 per cent. of the total charge is always in the circular path. In other words, the volume of the charge between r_1 and r_2 (Fig. 5) is only 56.65 per cent. of the total charge, the remaining 43.35 per cent. being spread out over the rest of the mill and following the parabolic path.

The exact analytical determination of the variation in the volume of the total charge as K varies is very complicated and will not be gone into here. A very close approximation can be made, however, by use of the equation,

$$K = -0.024 + 0.39\sqrt{7 - 10P} \qquad (20)$$

in which P is the fractional part of the entire volume of the mill that is occupied by the charge when the mill is stationary. It should be noted that the charge will contain a considerable proportion of voids. These are, of course, included in the space occupied by the charge.

19. Power

From equation (8) it appears that $V_b^2 = 16kgr^2 - 32k^3gr^4 + 16k^5gr^6$, but the kinetic energy $e = \frac{wv^2}{2g}$, or in this case, $e = w(8kr^2 - 16k^3r^4 + 8k^5r^6)$, which is the energy possessed by any particle of weight w, and radius r, at the end of its parabolic path, which is available for the purpose of crushing ore. Then the total energy possessed by the particles of radius between r_1 and r_2 is expressed by the equation,

$$\int_{r_2}^{r_1} e = w\left[\left(\frac{8}{3}kr^3 - \frac{16}{5}k^3r^5 + \frac{8}{7}k^5r^7\right)\right]_{r_2}^{r_1}$$

But $\qquad k = 1.226n^2$ and $r_2 = Kr_1$; then

$$E = w[3.269n^2r_1^3(1 - K^3) - 5.8968n^6r_1^5(1 - K^5) + 3.1656n^{10}r_1^7(1 - K^7)]$$

But $\qquad n = \dfrac{0.8158}{\sqrt{r_1}\sqrt[4]{1 + K^2}}$ for best theoretical efficiency; whence

$$E = wr_1^2\left[2.1756\frac{(1 - K^3)}{(1 + K^2)^{1/2}} - 1.7382\frac{(1 - K^5)}{(1 + K^2)^{3/2}} + 0.41333\frac{(1 - K^7)}{(1 + K^2)^{5/2}}\right]$$

In this equation, if W is the entire weight of the charge, then E represents the foot-pounds of energy delivered each time the charge passes through one cycle. Then since there are 1.444 cycles per revolution, and $n = \frac{0.8158}{\sqrt{r_1}\sqrt[4]{1 + K^2}}$ rev. per sec., the number of foot-pounds per second is represented by the equation,

$$E = Wr_1^{3/2}\left[2.5472\,\frac{(1 - K^3)}{(1 + K^2)^{1/8}} - 2.0351\,\frac{(1 - K^5)}{(1 + K^2)^{3/8}} + 0.48394\,\frac{(1 - K^7)}{(1 + K^2)^{5/8}}\right] \tag{21}$$

$$\text{or Hp.} = Wr_1^{3/2}\left[0.004467\,\frac{(1 - K^3)}{(1 + K^2)^{1/8}} - 0.003700\,\frac{(1 - K^5)}{(1 + K^2)^{3/8}} + 0.000880\,\frac{(1 - K^7)}{(1 + K^2)^{5/8}}\right] \tag{22}$$

This formula gives the power output and therefore input to the mill when the weight of the charge is W, in pounds, the radius of the mill is r_1, in feet, and the value of K and the speed N are as given by formulas (20) and (13). In other words, formula (22) gives the power required to operate the mill at the most efficient speed for any ball charge. In Table 16 the horsepower required has been computed for certain operating conditions. Any table or set of curves covering all conditions would be too large and complicated to include in this paper; the formulas may, however, be applied to any particular condition.

TABLE 16.—*Horsepower Required per Foot of Mill Length*

Internal Diam. of Mill, Ft. ($2r_1$)	Portion of Mill Volume Occupied by Charge					
	0.1	0.2	0.3	0.4	0.5	0.6
1	0.0023	0.0099	0.022	0.042	0.065	0.093
2	0.0255	0.110	0.254	0.46	0.73	1.04
3	0.1087	0.463	1.07	1.94	3.07	4.38
4	0.288	1.24	2.87	5.22	8.25	11.78
5	0.64	2.72	6.29	11.43	18.07	25.74
6	1.20	5.16	11.88	21.47	34.14	48.69
7	2.06	8.85	20.43	37.06	58.61	83.53
8	3.26	14.12	32.54	59.08	93.46	133.32
9	4.96	21.32	49.09	89.31	141.24	201.33
10	7.13	30.81	71.06	129.00	204.07	291.10

NOTE.—In this table the mill is assumed to be operating at the most efficient speed, as given in Table 17, and the charge is assumed to weigh 325 lb. per cu. foot.

20. CONSIDERATION OF A DEFINITE CASE

The actual application of the formulas to a definite problem may be instructive. Consider an 8 by 6-ft. cylindrical mill charged with 28,000

lb. (12,700 kg.) of steel balls. If the balls are made of steel weighing 500 lb. per cu. ft., and are all of one size, it may be shown that the charge will weigh 74.05 per cent. of 500 lb., or 370.25 lb. per cu. ft. The charge will then occupy 28,000 ÷ 370.25 = 75.6 cu. ft. (2.14 cu. m.) of space in the mill. The factor 75.05 per cent. is derived on the assumption that the spheres are equal; in the case of a mill, the space being limited and the balls not of one size, 65 per cent. is probably more nearly correct. Using this factor, the charge would weigh 325 lb. per cu. ft., and would therefore occupy 86 cu. ft. (2.23 cu. m.). The volume of an 8 by 6-ft. mill is 301 cu. ft. (8.5 cu. m.), hence the charge occupies 28.6 per cent. of the total volume. From formula (20), when the charge occupies 28.6 per cent. of the volume of the mill, the factor K is 0.770. The speed of the mill, by formula (13), is 21.75 r.p.m., and the power, by formula (22), is 181.5 hp. Angle α will then be given by formula (15):

$$\cos \alpha_1 = \frac{0.8165}{\sqrt{1+K^2}} = \frac{0.8165}{\sqrt{1+0.762^2}} = 0.6490;\ \alpha_1 = 49° \ 32'$$

$$\cos \alpha_2 = K \cos \alpha_1 = 0.4948;\ \alpha_2 = 60° \ 20'$$

$$r_2 = Kr_1 = 0.762 \times 4 = 3.048 \text{ ft.}$$

$$\beta = 3\alpha_1 - 90° = 58° \ 36';\ \beta_2 = 3\alpha_2 - 90° = 91°.$$

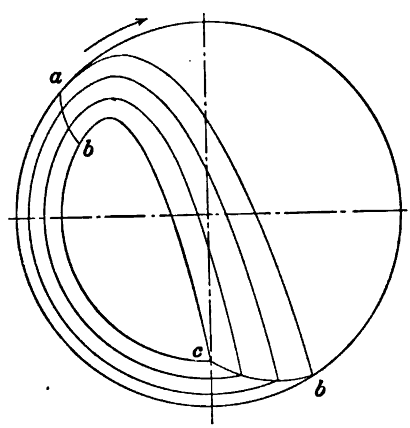

Fig. 7.—Paths of travel of particles in an 8 by 6 ft. ball-mill. 28,000-lb. ball load occupying 28.6 per cent. of mill volume. Speed of mill 21.75 r.p.m. 15,860 lb. of balls are traveling in the circular path. 12,140 lb. of balls are traveling in the parabolic path.

From these results and formula (2), which gives other values of r for various values of α, it is possible to plot the outline of the charge, as

is shown in Fig. 7. The particular path of any ball can be plotted by use of equation (3*a*).

21. Summary of Ball-mill Mechanics

Notation

r = radius to any particle p.
r_1 = radius of mill.
r_2 = inner radius of charge.
R = radius of gyration of charge near ao.
α = angle from vertical to r.
α_1 = angle from vertical to r_1.
α_2 = angle from vertical to r_2.
α_R = angle from vertical to R.
β = angle from horizontal to r.
β_1 = angle from horizontal to r_1.
β_2 = angle from horizontal to r_2.
n = speed of mill in rev. per sec.
N = speed of mill in rev. per min.
N^1 = critical speed of mill in rev. per min.
V_b = relative velocity of particle at od, ft. per sec.
w = weight of portion of charge, lb.
W = weight of entire charge, lb.
P = fraction of mill volume occupied by charge.
g = a constant = 32.2 ft. per sec. per sec.

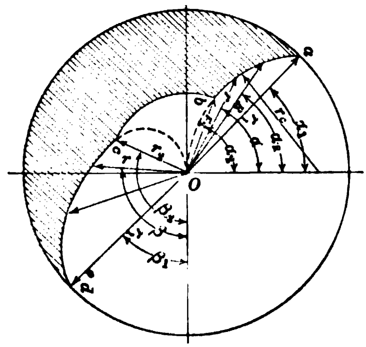

Fig. 8.

k = a constant = $\frac{4\pi^2 n^2}{g}$ = $1.226n^2$.
K = a constant = $\frac{r_2}{r_1}$.
H = height of charge in mill at rest.
E = kinetic energy, foot-pounds.
C_n = cycles per revolution.
rc = radius of circle oa.

General Equations

(2) $$\cos\alpha = kr = 1.226rn^2$$

(2*a*) $$rc = \frac{0.408}{n^2}$$

(2*b*) $$\cos\alpha_R = 0.8670r_1n^2\sqrt{1+K^2}$$

(3) $$N' = \frac{54.19}{\sqrt{r_1}}$$

(3*a*) $$y = x\tan\alpha - \frac{0.613n^2x^2}{\cos^4\alpha}$$ (equation of parabola)

(6) $$\beta = 3\alpha - 90°$$

(8) $$V_b^2 = 16rg\cos\alpha\sin^4\alpha$$

(10) For V_b max., $\alpha = 54° \, 44'$

(11*a*) $$r_2 = Kr_1$$

Relations when Operating at Best Theoretical Efficiency

(8a) $V_b \text{ max.} = \dfrac{7.88}{n}$

(8b) $V_b \text{ min.} = \sqrt{16Kr_1g \cos \alpha_2 \sin^4 \alpha_2}$

(10) $\alpha_B = 54° \, 44'$

(11) $K = \sqrt{\dfrac{0.443}{r_1^2 n^4} - 1}$

(12) $n = \dfrac{0.8158}{\sqrt{r_1}\sqrt[4]{1 + K^2}}$

(13) $N = \dfrac{48.95}{\sqrt{r_1}\sqrt[4]{1 + K^2}}$

(14) $\cos \alpha = \dfrac{0.8165r}{r_1} \cdot \dfrac{1}{\sqrt{1 + K^2}}$

(15) $\cos \alpha_1 = \dfrac{0.8165}{\sqrt{1 + K^2}}$

(16) $\cos \alpha_2 = \dfrac{0.8165K}{\sqrt{1 + K^2}} = K \cos \alpha_1$

(19) C_n average $= 1.444$

(20) $K = -\,0.024 + 0.39\sqrt{7 - 10P}$ (very nearly)

(22) $\text{Hp.} = Wr_1^{3/2}\left[0.004467 \dfrac{(1 - K^3)}{(1 + K^2)^{1/2}} - 0.0037 \dfrac{(1 - K^5)}{(1 + K^2)^{3/2}} + 0.00088 \dfrac{(1 - K^7)}{(1 + K^2)^{5/2}}\right]$

By use of these equations, with any given set of conditions, it is possible to determine the geometrical shape of the charge in the mill, the horsepower absorbed by it, the velocity of the blow struck by any ball, and the number of blows struck by any ball. The equations show also the relation that should exist between speed, diameter of mill and size of charge in order to secure the maximum theoretical efficiency.

22. Comparison of Observed and Calculated Curves

In order to observe how closely theory and practice agree, a small model mill 3 in. (76.2 mm.) in diameter and 2 in. (50.8 mm.) long was made, having a bearing at only one end so that the other could be closed by a piece of glass through which the action of the charge could be observed. The method of comparison consisted in introducing a weighed charge of fine sand, computing the best operating speed, and drawing the outline of the charge according to the preceding theory. The mill was then operated at this speed, and photographed. The comparison be-

tween the photograph and the drawing shows how closely theory and practice agree. No accurate data as to the power required could be secured on this small model. A number of these photographs and the corresponding drawings are shown.

The similarity between the photograph of the mill in actual operation and the theoretical drawing is very striking, especially when the mill contains a large charge. When the charge is small, the difference appears greater; this is because all interference between the particles causes them to fall into the open space near the center of the mill. The photographs could not be made to show clearly the fact that these particles were accidental; it is apparent, however, when actually watching the mill run, that the particles in the central space are only occasional, as compared with the outer band. While the results of interference are more evident in the small charge than in the large one, the actual amount of interference is greater in the large charge than in the small. This is evident when the cause of this interference is considered.

The curve *a–b* (Fig. 5) shows the boundary line between the circular and the parabolic paths. Each particle, as it passes the line *a–b*, starts on its parabolic path in a direction perpendicular to the radius of the mill through that point. It is evident that the perpendicular to the radius at *p* would intersect the perpendicular to the radius at *a* if it were produced far enough. If the two particles considered are closer together than *a* and *p* on the curve *a–b*, the intersection between the lines of initial direction are closer to the points considered. If the two points are adjacent on the curve *a–b*, it is apparent that the intersection will be very close to the points and will, in fact, take the form of a slight crowding action between the particles. The result of this will be a slight deformation of the curve through which the particle travels. This will be just as prominent in a small charge as in a large one, although the results will be more apparent in the small charge.

It may also be shown that when the size of the charge exceeds 0.4 the volume of the mill, there will be a tendency for the particles near the center of the mass to crowd one another. This is, however, not at all serious and could probably never be detected in operation, but as previously stated, when the mill is filled beyond 0.64 of its volume, the interference becomes quite important and the mill probably could not be made to operate efficiently when more than 0.6 full.

It appears from the photographs that there is a certain amount of movement between the particles at the end of the parabolic path which causes the actual parabolic path to end sooner than the theoretical path. This motion between the particles is due to the fact that each particle must change its direction of travel and move at about right angles to its original path. This change in direction requires time and reacting forces; if the force is small the time will be long and the agitation great. If the

force is large the time will be small and the agitation small. Therefore, when the mill speed is low, this zone of agitation is wide, as shown in Fig. 14. In this agitation zone grinding is done by attrition, but above it, the crushing is done by impact.

While these photographs and drawings were made to illustrate the action of the particles in the charge of a 3-in. mill, they also show the action in mills of any size when operated at the most efficient speed, as given by formula (13). In Table 17, the speeds have been computed for various sizes of mills and charges. In each case, the illustration that shows the position of the charge for the particular operating condition is indicated.

TABLE 17.—*Speed of Mill for Best Theoretical Efficiency* (N)

Inside Diam. of Mill, Ft. ($2r_1$)	Portion of Mill Volume Occupied by Charge at Rest					
	0.1	0.2	0.3	0.4	0.5	0.6
1	59.19	60.45	61.82	63.36	65.10	67.01
2	41.88	42.75	43.72	44.81	46.04	47.40
3	34.19	34.90	35.69	36.58	37.58	38.69
4	29.61	30.22	30.91	31.67	32.55	33.51
5	26.48	27.04	27.64	28.34	29.11	29.96
6	24.18	24.69	25.24	25.88	26.58	27.36
7	22.38	22.85	23.36	23.94	24.60	25.32
8	20.94	21.38	21.86	22.40	23.02	23.70
9	19.74	20.15	20.60	21.13	21.70	22.34
10	18.72	19.12	19.56	20.04	20.59	21.20
Illustrated by Figs.......	..	9	10	11	12	13

Table computed by use of Formulas (20) and (13).

TABLE 18.—*Speeds Corresponding to Given Charge Outline, R.p.m.*

Inside Diam. of Mill, Ft. ($2r_1$)	Illustration Number				
	14	11	15	16	17
1	58.00	63.50	76.00	80.99	87.99
2	41.02	44.91	53.75	57.28	62.23
3	33.48	36.67	43.88	46.76	50.81
4	29.00	31.74	37.99	40.50	44.00
5	25.54	28.39	33.99	36.23	39.35
6	23.68	25.93	31.04	33.07	35.93
7	21.92	24.00	28.72	30.61	33.26
8	20.50	22.40	26.88	28.63	31.12
9	19.33	21.17	25.34	26.99	29.33
10	18.34	20.08	24.04	25.62	27.83

Portion of volume occupied by charge (P) is 0.4 in all cases.

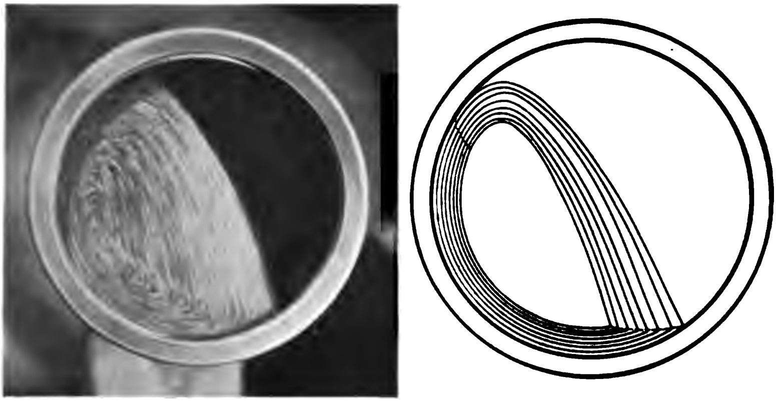

FIG. 9.—P = 0.2.

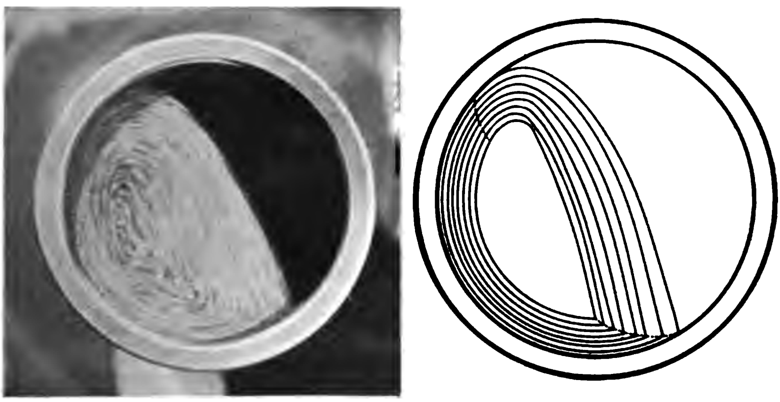

FIG. 10.—P = 0.3.

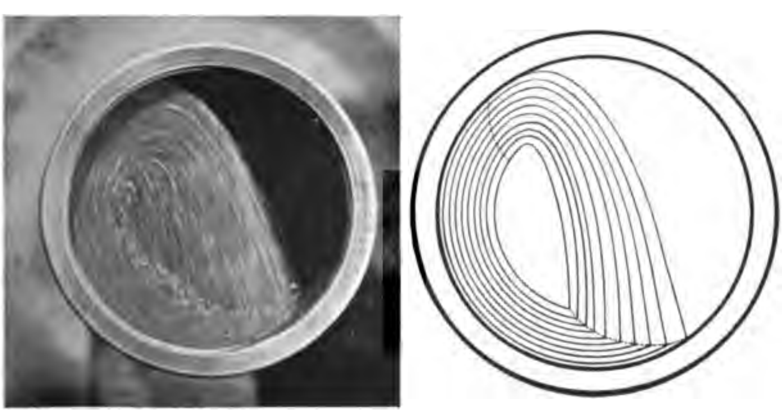

FIG. 11.—P = 0.4.

FIGS. 9–11.—SHOW RELATION BETWEEN ACTUAL AND THEORETICAL CURVES AT CORRECT MILL SPEEDS.

In Figs. 14, 15, 16 and 17, the effects of high and low speeds are shown. In all of these photographs the mill was 0.4 full, the operation at the proper speed being shown in Fig. 11. Table 18 shows the speed at which the charge in mills of various diameters would appear as illustrated.

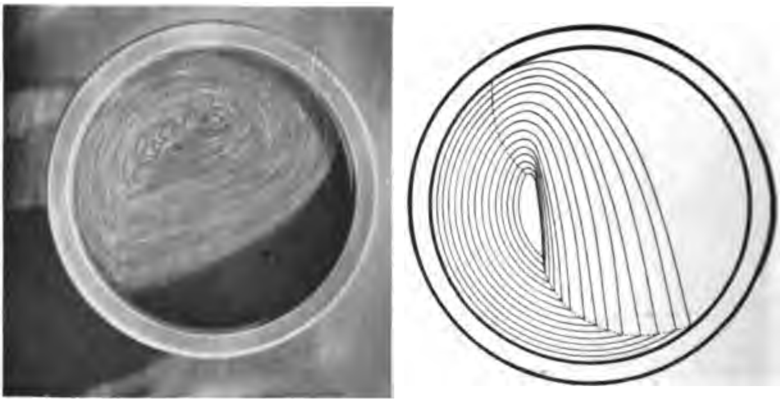

FIG. 12.—P = 0.5.

FIG. 13.—P = 0.6.

FIGS. 12–13.—SHOW RELATION BETWEEN ACTUAL AND THEORETICAL CURVES AT CORRECT MILL SPEEDS.

23. CONCLUSIONS AS TO BALL-MILL OPERATION

In this whole discussion, only the force of gravity and centrifugal force have been considered. In a mill containing water and ore as well as balls, the force of adhesion is to be considered. This force not only tends to hold the balls and ore together but also tends to hold them

against the lining of the mill. Just how important this force may be under ordinary operating conditions is hard to say. It was shown, however, in the little model mill, that adhesion tended to hold the particles together in their parabolic paths and almost entirely eliminated the accidental particles that fall near the center of the mass. It is impossible to apply the results secured in a small mill to a large mill in this respect, however, as adhesion varies inversely with the size of the particles considered.


FIG. 14.—LOW SPEED. FIG. 15.—HIGH SPEED.


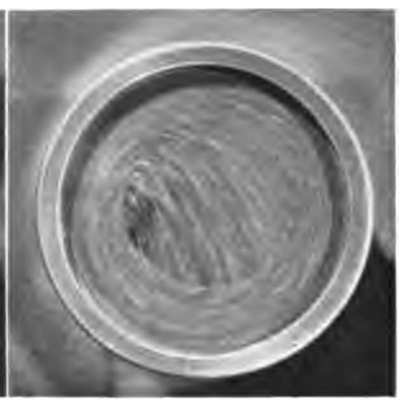

FIG. 16.—HIGH SPEED. FIG. 17.—HIGH SPEED.

FIGS. 14–17.—MILL OPERATING AT INCORRECT SPEEDS.

Adhesion also varies with the moisture, so the mill operator has a convenient means of controlling this force so as to produce the best results. The amount of moisture in the pulp for best efficiency will vary with the nature of the ore, the nature of the ball charge, and the nature of the mill. With a mill charge of large steel balls, adhesion will not

affect the operating conditions to any considerable extent unless the pulp is made very thick. The tendency would then be for the balls to stick to the lining and revolve with it.

It is very important to prevent slipping between the charge and the lining of the mill; the tendency to slip is much smaller with large charges than with small ones. If the friction between the charge and the lining of the mill is not great enough to carry the particles up to the curve a–b, the efficiency of the mill will be very greatly reduced and the lining of the mill will be rapidly worn away. Flat sides will also appear on the balls and the cycle of the charge will be slow and irregular. In an open-trunnion discharge mill, the pulp will not flow from the mill regularly but will come in pulsations. Lifters or roughened liners are therefore desirable, as they insure a greater coefficient of friction.

The following conclusions may be stated:

1. By use of formulas (20) and (13), the proper theoretical speed for the operation of the mill may be computed.

2. This speed is correct only when there is no slipping between the charge and the lining of the mill, and when the pulp is not so thick as to produce strong adhesion between the particles.

3. In actual practice it may be found that more effective crushing can be done at some other speed, but it would appear that the variations above or below this theoretical speed should be small.

4. When operating at the speed shown by formula (13) the crushing is done largely by impact.

5. At speeds lower than N (equation 13) the proportion of the crushing done by attrition is increased.

6. At speeds higher than N (equation 13) the proportion of the crushing done by impact is increased.

7. The amount of crushing done depends upon the number of blows struck and the work done at each blow.

8. The number of blows struck can be increased by increasing the number and decreasing the size of the balls.

9. The work done at each blow can be increased by increasing the weight of the ball and by increasing the diameter of the mill.

10. From this it follows that mills of larger diameter should be charged with smaller balls and mills of smaller diameter with larger balls, when working on the same feed.

11. The proper operating speeds of ball-mills vary inversely as the square-root of the diameters.

12. The proper operating speed of a ball-mill increases as the size of the ball load increases.

13. Due to interference between the balls, the volume of the charge should not be over 60 per cent. of the volume of the mill.

14. Unless great care is exercised to prevent slippage, the volume of

the ball charge should not be less than 20 per cent. of the volume of the mill.

15. It would then seem that a ball charge that occupies between 25 and 50 per cent. of the volume of the mill will give the most satisfactory results.

16. In an 8-ft. (2.4 m.) mill running at 22 r.p.m., with a 28,000-lb, (12,700 kg.) charge of 2-in. (50.8-mm.) balls, there will be an average of about 1,000,000 blows per minute; each of these blows will be equivalent to dropping a 2-in. ball 5 ft. (1.5 m.).

III. BALL WEAR

In the previous discussion the fact was established that the work done by a ball when it strikes at the end of its parabolic path is proportional to its weight and velocity; then, since the velocity may be considered as constant for all the balls in the mill, the work done by a ball is proportional to its weight. Since the amount of ore crushed varies as the work done upon it, it seems reasonable that the amount of steel worn from the balls varies as the work done upon them; in other words, the ball wear is proportional to the work done. But it has been shown that the work done is proportional to the weight of the ball; hence, the wear is proportional to the weight of the ball, or

$$R = KW \tag{23}$$

in which R is the rate of wear of any ball of weight W; K is a constant and depends upon the operating conditions of the mill and the resistance of the material from which the balls are made. In order to establish the accuracy of this equation, some transformations are necessary.

After a ball-mill has been in continuous and steady operation for, say, a year, during which time balls of only one diameter have been added at regular intervals, it may be assumed that the ball charge has reached a constant working condition. In this constant state, there is no change in the charge from day to day, either as to the weight of the charge or the average diameter of the balls composing it. Any particular ball enters the mill at a maximum diameter D, and gradually wears down until it is completely worn away; the residual charge of balls, however, always remains the same.

Suppose these balls composing the residual charge to be laid out in a line, beginning with the largest and ending with the smallest. Suppose intervals to be marked off along this line so that all of the balls of diameter from D_m to D_1 are in the first interval, from D_1 to D_2 in the second interval, D_2 to D_3 in the third interval, and so on. Let N_1, N_2, N_3, etc., represent the number of balls in each interval, and let D'_1, D'_2, D'_3, etc., represent the mean diameters of the balls in their respective intervals.

In the constant state, the number of balls in each of these intervals does not vary, and when a new ball of diameter D_m is added to the first interval, a ball of diameter D_1 passes into the second interval, and so on down the line, until in the last interval one ball is entirely worn away. Then, as time goes on, each ball of diameter D_m which was added gradually passes along the line until its diameter becomes D_1 when it passes from the first interval into the second. If in time T, N_w balls of diameter D_m are added, then N_w balls will pass from each interval into the next following interval. The time T required for any ball to pass through any interval may then be expressed by the formula,*

$$T = \frac{N'_t}{N_w} \tag{24}$$

or the time required for any ball to reduce its diameter from D_a to D_b is equal to the total number of balls in the interval divided by the number of balls added to the intervals, or passing from the interval during this time.

If, as previously suggested, the wear varies as the weight of the ball, then, $R = KW = K\frac{\pi}{6}SD^3$, in which S is the weight of the material from which the balls are made and D is the diameter of the ball in question.

This formula shows the rate of wear at any instant. Since rate is always equal to the differential of space with respect to time, then $R = \frac{dw}{dt}$ in which dw is the weight of material worn off in a very small interval of time, dt.

But $w = \frac{\pi S}{6} D^3$ and $dw = \frac{3\pi S}{6} D^2 dD$.

$$\text{Then } \frac{\frac{3\pi S}{6} D^2 dD}{dt} = R = K\frac{\pi S}{6} D^3,$$

$$\text{or simplifying, } \frac{3dD}{dt} = KD, \text{ or } \frac{3dD}{KD} = dt.$$

$$\text{Then } \int_{D_b}^{D_a} dt = \frac{3}{K}\int_{D_b}^{D_a} \frac{dD}{D}, \text{ or } T = \frac{3}{K}\log_\epsilon \frac{D_a}{D_b} = \frac{6.9}{K}\log_{10}\frac{D_a}{D_b} \tag{25}$$

In this formula, T is the time required to reduce the diameter of the ball from D_a to D_b.

$$\text{Since } T = \frac{N'_t}{N_w},\ N'_t = TN_w = \frac{6.9N_w}{K}\log_{10}\frac{D_a}{D_b} \tag{26}$$

This formula gives the total number of balls of diameter between D_a and D_b.

* The writer is indebted to Dr. F. H. MacDougall of the University of Minnesota for assistance in deriving these formulas.

The rate of wear is equal to the amount worn off divided by the time required; but the amount worn off in any interval is $\frac{1}{6}\pi S(D_a^3 - D_b^3)$.

Then $R = \frac{1/6\pi S(D_a^3 - D_b^3)}{T}$; or $K\frac{\pi}{6}S(D'_a)^3 = \frac{1/6\pi S(D_a^3 - D_b^3)}{\frac{N'_t}{N_w}}$;

or $K(D'_a)^3 = \frac{N_w(D_a^3 - D_b^3)}{N'_t}$; or $N'_t = \frac{N_w(D_a^3 - D_b^3)}{K(D'_a)^3}$

The total weight of the balls in any interval is equal to the number of balls in the interval times the mean weight of these balls,

or
$$W'_t = N'_t \times \frac{(D'_a)^3\pi S}{6};$$
then
$$W'_t = \frac{N_w(D_a^3 - D_b^3)}{K(D'_a)^3} \times \frac{(D'_a)^3\pi S}{6}$$
or
$$W'_t = \frac{\pi S N_w(D_a^3 - D_b^3)}{6K} \tag{27}$$

But the sum of the weights of the balls in each section is the weight of the entire ball charge, or

$$\begin{aligned} W_t &= W_1 + W_2 + W_3 + W_4, \text{ etc.} \\ &= \frac{\pi S N_w}{6}\,\frac{(D_m^3 - D_1^3)}{K} + \frac{\pi S N_w(D_1^3 - D_2^3)}{6K}, \text{ etc.} \\ &= \frac{\pi S N_w}{6K}(D_m^3 - D_1^3 + D_1^3 - D_2^3, \text{ etc.}) = \frac{\pi S N_w}{6K}(D_m^3) \end{aligned} \tag{28}$$

and
$$K = \frac{\pi S N_w D_m^3}{6W_t} = \frac{R_t}{W_t} \tag{29}$$

Since
$$W'_t = \frac{\pi S N_w(D_a^3 - D_b^3)}{6K},$$
$$W'_t = \frac{W_t(D_a^3 - D_b^3)}{D_m^3} \tag{30}$$

which is the weight of balls in one interval. The per cent. weight of balls in an interval is given by the formula,

$$\%\, W'_t = \frac{D_a^3 - D_b^3}{D_m^3} \times 100 \tag{31}$$

The average weight of the balls of diameter between D_a and D_b is equal to the total weight of the balls divided by the total number of balls, or

$$W \text{ avg.} = \frac{W'_t}{N'_t} = \frac{\frac{W_t(D_a^3 - D_b^3)}{D_m^3}}{\frac{3N_w}{K}\log_\epsilon \frac{D_a}{D_b}} = \frac{KW_t(D_a^3 - D_b^3)}{3N_w D_m^3 \log_\epsilon \frac{D_a}{D_b}} \tag{32}$$

But since W avg. $= (D'_a)^3\frac{\pi S}{6}$,

then
$$D'_a = \sqrt[3]{\frac{2KW_t(D_a^3 - D_b^3)}{D^3_M\,\pi S N_w \log_\epsilon \frac{D_a}{D_b}}} = \sqrt[3]{\frac{1}{3}\,\frac{D_a^3 - D_b^3}{\log_\epsilon \frac{D_a}{D_b}}} \tag{33}$$

By use of formula (31) it is possible to compute the actual screen analysis of the balls in the mill. If the balls are removed from the mill when they reach a certain minimum diameter, D_o, formula (31) becomes,

$$\% W'_t = \frac{D_a^3 - D_b^3}{D_m^3 - D_o^3} \qquad (34)$$

in which D_a and D_b are the upper and lower limits of the diameter for any desired interval, D_m is the diameter of the balls charged to the mill, and D_o is the diameter below which the balls are removed from the mill.

It should be remembered, however, that these formulas (31) and (34) hold true only provided that the balls wear down at a rate proportional to their weight. It would seem that if the percentage weight computed by formulas (31) and (34) agreed reasonably closely with the actual results secured by carefully screening a ball charge after the mill had been in operation a sufficient length of time for the charge to become steady, and if this agreement could be secured in a number of cases under different conditions, it would be convincing evidence that the ball wear varies with the weight of the ball.

24. Data on Ball Charges

In an endeavor to follow this plan, the attempt has been made to secure reliable data showing the screen analysis of ball charges which have been in steady use for a long period. It seems to be difficult to secure reliable information on this subject but the following results seem to indicate the truth of this law of ball wear.

The screen analysis of the ball charge of an 8-ft. by 22-in. (2.4-m. by 55.8-cm.) Hardinge conical mill shown in Table 19 was made at the

TABLE 19.—*Screen Analysis of Ball Load at Miami*

Diameter, In.	Weight, Lb.	Actual Per Cent. Wt.	Computed Per Cent. Wt.*
2.0 to 1.8	4,080	27.46	27.10
1.8 to 1.6	3,120	21.00	21.70
1.6 to 1.4	2,630	17.70	16.90
1.4 to 1.2	1,908	12.84	12.70
1.2 to 1.0	1,344	9.04	9.10
1.0 to 0.8	854	5.75	6.10
0.8 to 0.6	500	3.36	3.70
0.6 to 0.4	284	1.91	1.90
Below 0.4	140	0.94	0.80
Total	14,860	100.00	100.00

* Computed from equation, $\% \text{ Wt.} = \frac{D_a^3 - D_b^3}{D_m^3} \times 100$.

Miami Copper Co.'s plant after the mill had been operating for a year with a ball load of 14,800 lb. (6713 kg.) which was maintained by the addition of 400 lb. (181 kg.) of 2-in. (50.8-mm.) steel balls daily.

In this table, the actual per cent. weight obtained by weighing the balls is compared with the theoretical per cent. weight computed by use of formula (30). The two columns of figures are almost identical, thereby showing the accuracy of the formula and the truth of the law of ball wear.

At the Golden Cycle Mining and Reduction Co.'s plant a dry crushing test was made on a 6 ft. 2 in. by 6-ft. (1.85 by 1.8-m.) Kominuter ball-mill. The mill was operated for 694 hr., during which time 4825 lb. (2188 kg.) of 5½-in. (139.7-mm.) balls were added. The original ball load in the mill was 6614 lb. (3000 kg.) and the load at the end of the 694 hr. was 6338 lb. (2874.8 kg.). During this time, 590 lb. (267.6 kg.) of balls less than 3 in. (76.2 mm.) in diameter were discarded from the mill. The screen analysis of the ball charge at the end of the operation is shown in Table 20.

TABLE 20.—*Screen Analysis of Ball Load at Golden Cycle Mill*

Diameter, In.	Weight, Lb.	Actual Per Cent. Wt.	Computed Per Cent. Wt.*
5.5 to 5.3	814	12.83	12.32
5.3 to 5.1	795	12.54	11.43
5.1 to 4.9	836	13.18	10.57
4.9 to 4.7	542	8.55	9.74
4.7 to 4.5	545	8.59	8.94
4.5 to 4.3	535	8.44	8.18
4.3 to 4.1	430	6.78	7.46
4.1 to 3.9	352	5.55	6.76
3.9 to 3.7	268	4.23	6.10
3.7 to 3.5	340	5.36	5.48
3.5 to 3.3	333	5.25	4.89
3.3 to 3.1	286	4.52	4.33
3.1 to 2.9	265	4.18	3.80
Total	6341	100.00	100.00

*Computed by formula, $\% \text{ Wt.} = \frac{Da^3 - Db^3}{Dm^3 - Do^3}$.

The slight irregularity in these results may be explained by the fact that at one time during the test, after about 400 hr., twenty-two 5½-in. balls were added at one time. This may explain the irregularities at about 5-in. size.

TABLE 21.—*Screen Analysis of the Ball Charge Under Various Conditions*

Charged at, Inches	5	5	5	5	5	4	4	4	4	3	3	3	3	2	2	2	2	2
Removed at, Inches	0	1	2	3	4	0	1	2	3	0	1	2	2.5	0	0.50	0.75	1.00	1.50
Size, Inches	Per Cent. Weight																	
5.00 to 4.75	14.26	14.38	15.24	18.19	29.23													
4.75 to 4.50	12.83	12.93	13.70	16.36	26.28													
4.50 to 4.25	11.49	11.58	12.27	14.65	23.54													
4.25 to 4.00	10.22	10.30	10.92	13.04	20.95													
4.00 to 3.75	9.02	9.09	9.64	11.51	......	17.61	17.89	20.13	30.47									
3.75 to 3.50	7.88	7.94	8.42	10.05	......	15.39	15.63	17.59	26.62									
3.50 to 3.25	6.84	6.90	7.31	8.73	......	13.36	13.57	15.27	23.11									
3.25 to 3.00	5.86	5.91	6.26	7.47	......	11.45	11.63	13.08	19.80									
3.00 to 2.75	4.96	5.00	5.30	......	......	9.69	9.84	11.07	......	22.96	23.84	32.63	54.52					
2.75 to 2.50	4.14	4.17	4.42	......	......	8.08	8.21	9.24	......	19.15	19.89	27.22	45.48					
2.50 to 2.25	3.39	3.42	3.62	......	......	6.63	6.73	7.57	......	15.70	16.30	22.31						
2.25 to 2.00	2.71	2.73	2.90	......	......	5.30	5.38	6.05	......	12.56	13.04	17.84						
2.00 to 1.75	2.11	2.13	......	......	......	4.13	4.20	......	......	9.78	10.16	......	......	33.00	33.54	34.82	37.72	57.14
1.75 to 1.50	1.58	1.59	......	......	......	3.09	3.14	......	......	7.33	7.61	......	......	24.75	25.16	26.12	28.29	42.86
1.50 to 1.25	1.14	1.16	......	......	......	2.23	2.27	......	......	5.30	5.50	......	......	17.87	18.16	18.86	20.42	
1.25 to 1.00	0.76	0.77	......	......	......	1.48	1.51	......	......	3.52	3.66	......	......	11.87	12.07	12.53	13.57	
1.00 to 0.75	0.46	......	......	......	......	0.91	......	......	......	2.15	......	......	......	7.25	7.38	7.67		
0.75 to 0.50	0.24	......	......	......	......	0.45	......	......	......	1.07	......	......	......	3.63	3.69			
0.50 to 0.25	0.09	......	......	......	......	0.17	......	......	......	0.41	......	......	......	1.38				
0.25 to 0.00	0.02	......	......	......	......	0.03	......	......	......	0.07	......	......	......	0.25				
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

From the two tests reported, the agreement between the actual per cent. weight and the computed per cent. weight is as close as could be expected. One was on a wet-crushing conical mill, and the other was on a dry-crushing cylindrical mill, and as far as the available data are concerned, the law of ball wear seems to be proved. It may develop however, when more data are collected, that the wear, instead of being proportional to the cube of the diameter, will be proportional to some slightly higher or lower power.

25. Conclusions as to Ball Wear

1. In any mill, the rate at which the weight of any ball decreases is directly proportional to its weight.
2. In any mill, the rate at which the diameter of a ball decreases is directly proportional to its diameter.
3. In any mill, the rate at which the surface of any ball decreases is proportional to its surface.
4. Since the rate at which a ball loses weight varies as the work done upon it in the mill, it follows that the work done in wearing (or crushing) the ball, varies as the weight of the ball. This is seen to be Kick's law.
5. It then appears that Kick's law holds true for the ball wear in a rotating mill.
6. The natural tendency is for the small balls to accumulate in the mill charge
7. Since these small balls do very little crushing, and exclude ore and larger balls from the mill, if allowed to accumulate too long, a marked decrease in crushing efficiency will result.
8. Since the large ball is just as likely to strike the small pieces of ore and the small ball is just as likely to strike the large pieces of ore as the reverse, it would seem that all of the balls should be of a size to crush any of the particles of ore.
9. This means that the balls should be as nearly as possible of a uniform size.
10. Since spheres of uniform size provide the greatest amount of interstitial space, a mill charge composed of balls of uniform size will allow freer migration of the ore particles than a charge containing balls of different sizes.

26. Recapitulation of Ball-wear Formulas

N_w = number of balls added in time T to compensate for the ball wear.
N_t = total number of balls in the mill.
N'_t = total number of balls in any interval.
N_1, N_2, N_3, etc. = number of balls in the first, second, third, etc., intervals.
D = diameter of any ball under consideration.

D_m = diameter of balls added to compensate for wear.
D'_a = mean diameter of balls in any interval.
D_a = diameter at beginning of interval.
D_b = diameter at end of interval.
D_1, D_2, D_3, etc. = diameter of balls at end of first, second, third, etc., intervals.
W_t = total weight of balls in the mill.
W'_t = total weight of balls in any interval.
w = weight of any ball.
R = rate of ball wear.
R_t = loss in weight of the mill charge in time T. It is equal to $\frac{\pi}{6} D_m^3 SN_w$.
T = time required for any ball to pass through any interval.
S = weight of material from which balls are made.

(23) $R = KW$. Rate of wear for any ball of weight W.

(25) $T = \frac{6.9}{K} \log_{10} \frac{D_a}{D_b}$. Time to wear from D_a to D_b.

(26) $N'_t = \frac{6.9N}{K} \log_{10} \frac{D_a}{D_b}$. Number of balls between D_a and D_b.

(29) $K = \frac{\pi SN_w}{6W_t} D_m^3$. A constant for any ball charge.

(30) $W'_t = \frac{W_t(D_a^3 - D_b^3)}{D_m^3}$. Weight of balls between D_a and D_b, when all balls are allowed to wear out in the mill.

(31) $\% W'_t = \frac{D_a^3 - D_b^3}{D_m^3} \times 100$.

(32) $W \text{ avg.} = \frac{\pi s(D_a^3 - D_b^3)}{41.4 \log_{10} \frac{D_a}{D_b}}$. Mean weight of balls between D_a and D_b.

(33) $D'_a = \sqrt[3]{\frac{D_a^3 - D_b^3}{6.9 \log_{10} \frac{D_a}{D_b}}}$. Mean diameter of balls between D_a and D_b.

(34) $\% W'_t = \frac{D_a^3 - D_b^3}{D_m^3 - D_o^3}$. Per cent. of total ball charge between D_a and D_b when all balls smaller than D_o are removed from the mill.

IV. PRACTICAL APPLICATION OF THEORETICAL CONCLUSIONS

The question finally arises as to how fine-crushing practice can be improved by the application of any of the principles that have been set forth. It is felt that the chief benefit to the mill operator will be derived from the fact that he may be better acquainted with exactly what is going on inside the ball-mill under various conditions. He should have a mental picture of the action of the charge and know better how to correct the difficulties encountered. He should also have a better idea how to proceed in order to produce any desired result.

While it is possible mathematically, as has been shown, to calculate the proper mill speed for any definite volume of charge, the size of the balls to be used must be determined experimentally. The size of balls is a most important factor in crushing, and each different condition requires balls of a different size. Whether the ore is hard or soft, coarse or fine, does not affect the proper mill speed or the volume of the charge; these depend almost entirely upon the size, and possibly to some small extent on the characteristics of the mill. But the proper size of the balls can be determined only by a careful study of the existing conditions. Experimental data must here be resorted to and the following method is recommended as a good means for determining the exact size of the balls that should be used.

Charge the mill with large balls, say of 5-in. (127 mm.) diameter. A smaller size might be better, but balls should be used that are known to be too large. An ammeter or wattmeter should be connected in the circuit of the driving motor so that the operator may keep the ball load constant by observing the power required by the mill. For maintaining this constant ball load, only balls of the same diameter as are already in the mill should be added. That is, if the test is started with all 5-in. balls, at the end of 24 hr. these balls will all be, say $4\frac{3}{4}$ in.; the ball load should then be restored to its original weight by adding only $4\frac{3}{4}$-in. balls. Thus, each time balls are added a different size must be used.

In this manner the mill will be filled with balls of approximately uniform diameter at all times. Then by keeping the records of each day's run, it will be possible for the operator to determine just which size produced the best results under the conditions at hand. The ball charge should then be composed of balls as near this size as is practical and economical.

There are two methods of determining the proper size of the balls to be added at the end of each 24 hr. One method is to sample the ball charge and actually measure the balls. In some types of mills a sampler can be inserted through the discharge trunnion. If this is not possible the size of the balls can be computed, but samples should be obtained at certain intervals in order to check the computations. The method of computing the ball size comes directly from the ball-wear formula and is as follows:

First determine the ball wear for the previous 24 hr. This may be done by obtaining a rough calibration of the power meter in the motor circuit so that any definite decrease in power indicates a given decrease in the weight of the charge. This is, then the ball wear in pounds per day. Then in ball-wear formula (25), $T = \frac{6.9}{K} \text{Log}_{10} \frac{D_a}{D_b}$; but from (29), $K = \frac{R_t}{W_t}$. Then $T = \frac{6.9W_t}{R_t} \text{Log}_{10} \frac{D_a}{D_b}$. T is 1 day, W_t is the original weight

of the ball charge, and R_t is the ball wear for one day. Then $\text{Log}_{10} \frac{D_a}{D_b} = \frac{R_t}{6.9W_t}$. In this formula, R_t, W_t and D_a are all known, and it is only necessary to solve for D_b, the diameter of the balls to be added. If only R_t lb. of these balls are added, then any error in computing R_t will not accumulate but will be corrected on the following day.

The above method for determining the proper size of the balls will, of course, require the careful attention of some one outside the ordinary mill crew. It also calls for a large assortment of balls of various diameters. As compensation for the trouble and expense necessary for the proper carrying out of this experiment, the operator stands a good chance of increasing the ball-mill capacity by a very considerable amount.

Once the proper size of balls is determined, the charge should be maintained so that it is composed of balls as little larger and as little smaller than the average diameter ball as is possible. Just how closely the proper ball charge can be maintained depends upon the facilities and economic conditions at the plant. The removal of the small balls, which is the main difficulty, is not so serious as it may seem at first; proper equipment makes this easy and inexpensive. It is to be hoped that the makers of ball-mills will succeed in producing a mill that will automatically discard balls of any desired diameter as rapidly as they are formed.

Another point which will bear investigation is the classifier capacity. As has been pointed out, large circulating loads seem essential for best efficiency. Classification is cheap compared with fine crushing and a classification capacity in excess of the capacity of the ball-mill is very much to be desired.

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TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Effect of Rate of Temperature Change on Transformations in an Alloy Steel*

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(New York Meeting, February, 1919)

CONTENTS

INTRODUCTION

SINCE Böhler discovered, in 1903, on cooling certain alloy steels, the phenomenon of a new and lower temperature transformation than the usual Ar_{3-2-1} obtained by increasing the maximum temperature to which the material was heated, much has been published[1] connecting this phenomenon with a large number of dissimilar steels of high alloy content. From the fact that the transformation divides itself, taking place at two widely separated temperatures, it has been called a "split transformation." The significant facts established by recent investigators[2] are: that when the transformation occurs at the higher temperature Ar', troostite or a decomposition product is formed, and that when the transformation occurs at the lower temperature Ar'', the resulting structure is martensite. The terminology Ar' and Ar'' adopted here is that of Portevin.[3]

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* Contributed through the courtesy of the U. S. Bureau of Standards.

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[1] Yatsevitch: Recherches sur l'Acier à Coupe Rapide. *Rev. de Met.* (1918), **15**, 65–115. Bibliography to 1915.

[2] P. Dejean: Les Points Critiques de Refroidissement des Aciers Auto-Trempants et la Formation de la Troostite et de la Martensite. *Rev. de Met.* (1917), **14**, 641–675.

A. Portevin: Les Points de Transformation des Aciers Nickel-Chrome. *Rev. de Met.* (1917), **14**, 707–716.

C. A. Edwards: Initial Temperature and Critical Cooling Velocities of a Chromium Steel. *Jnl.* Iron and Steel Inst. (No. 1, 1916), **93**, 114–140.

[3] Portevin, *Loc. cit.*

Previous Investigations

Reviewing the work on this subject published in a recent issue of *Revue de Métallurgie* and referring in particular to his statement that martensite is a solution of carbide in alpha iron, Le Chatelier says:[4]

"How then can a theory already 20 years old demand new investigations? The reason for it is that we have not succeeded in proving directly the real presence of the transformation of iron during the very short duration of the quenching. The fall of temperature takes place at the rate of several hundred degrees per second and the observation of phenomena so rapid requires particularly sensitive methods of recording. I have attempted without success to observe the moment of the reappearance of the magnetic property during the quenching of bars 15 mm. square, but the inequalities of temperature from one point to another in the mass conceal the phenomenon. M. Chevenard,[5] in working on wires of a diameter 100 times smaller and using as a characteristic of the transformation of iron the change of length instead of the variation of magnetism, has surmounted for the first time the difficulties which seemed at first view insurmountable and he has done it with an extreme precision. The thermal measurements of Portevin and Garvin[6] and of Dejean[7] lead to the same conclusions, although in a less direct manner."

The results presented here add further confirmation of the theory of Le Chatelier though in a less direct manner than those of Chevenard. Thermal and microscopic data are brought forward here to establish the effect of rate of temperature change on the temperature and nature of the transformations in a steel of the composition: carbon 1.75, manganese 0.26, cobalt 2.90, chromium 15.0. Similar work has been done by Edwards[8] on a steel of the composition: carbon 0.63, chromium 6.15, silicon 0.07, manganese 0.17. He arrives at the conclusion, however, that "the maximum hardness was obtained when the thermal transformation had been entirely prevented, and when this was accomplished the steel was purely martensitic in structure."

The present work fails to confirm this statement, as does that of the investigators already referred to. Edwards was unable to observe the transformation Ar'' with the formation of martensite, probably for the reasons given by Rosenhain[9] in his discussion of Edwards' paper.

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[4] Henri Le Chatelier: La Trempe de l'Acier. *Rev. de Met.* (1917), **14**, 601–606.

[5] Pierre Chevenard: Dilatomètre Différential Enrégistreur. *Rev. de Met.* (1917), **14**, 610–640.

[6] Portevin and Garvin: Influence de la Vitesse de Refroidissement sur la Température de Transformation de la Structure des Aciers au Carbone. *Rev. de Met.* (1917), **14**, 607–609.

[7] P. Dejean: Les Points Critiques de Refroidissement des Aciers Auto-Trempants et la Formation de la Troostite et de la Martensite. *Rev. de Met.* (1917), **14**, 641–675.

[8] C. A. Edwards, *Loc. cit.*

[9] Walter Rosenhain: Discussion on Initial Temperature and Critical Cooling Velocities of a Chromium Steel. *Jnl.* Iron and Steel Inst. (No. 1, 1916), **93**, 147.

Yatsevitch,[10] Dejean,[11] and Honda[12] have used two or three cooling rates in their experiments with varying maximum temperatures and their results show, as do Edwards', that the transformation split occurs for lower values of the maximum temperature with faster cooling rates.

The previous investigators in this field have laid particular stress on the variation of the maximum temperature, the rate remaining constant, while the variation of rate, the maximum temperature remaining constant, has received little attention. The present work attempts to apply the latter method to the investigation of an alloy steel with the object of correlating the results of that method with those of the former and to establish the relations of the several phenomena observed.

Experimental Method

The method employed for obtaining the thermal curves was to heat the samples attached to the hot junction of a 0.5 mm. diameter platinum wire, 90 platinum − 10 rhodium thermocouple, in an electric vacuum furnace, taking potential measurements on a dial potentiometer and measuring the time interval on a chronograph, as described in Bureau of Standards *Scientific Paper* 213. The furnace, which was recently built at the Bureau, is a modified type of the one described by Rosenhain[13] and is in use at the National Physical Laboratory. It will be described at a later date and is admirable for the purpose, as extreme rates of temperature change can be obtained with smooth curves over long ranges.

Thermal Curves

The curves of Figs. 1 and 2 were plotted by the inverse-rate method from readings taken every 0.02 millivolt (approximately 2° C.) except for several extremely fast runs, which, however, are plotted on that basis. The curves of Fig. 1 are a preliminary series taken on sample A of about 10 gm. mass to locate the transformation ranges and without fully knowing the characteristics of the material. The data for the curves of Fig. 2 were taken on sample B, mass 0.81 gm., keeping the maximum temperature constant and extending the observations to lower temperatures than for sample A. The values given for the rate of temperature change were reduced from the inverse-rate curve observations taken on heating just before Ac_{1-3} and on cooling midway between Ar′ and Ar″.

[10] Yatsevitch, *Loc. cit.*

[11] P. Dejean, *Loc. cit.*

[12] Kôtarô Honda and Takejirô Murakami: On the Structure of Tungsten Steels and Its Change under Heat Treatment. *Sci. Rep.* Tohoku Imp. Univ. (1917) **6**, 235–283.

[13] Walter Rosenhain: Some Appliances for Metallographic Research. *Jnl.* Inst. Met. (No. 1, 1915), **13**, 164–172.

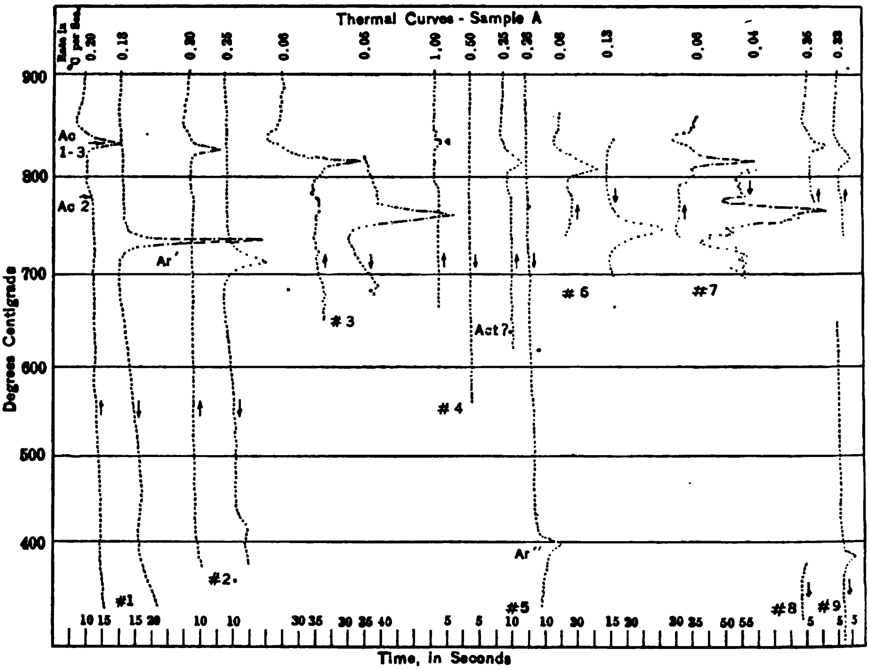
Thermal Curves - Sample A
Rate in °C per Sec.
Degrees Centigrade
Time, in Seconds
Ac 1-3
Ac 2
Ar'
Ar''
Act ?
#1
#2
#3
#4
#5
#6
#7
#8
#9

FIG. 1.

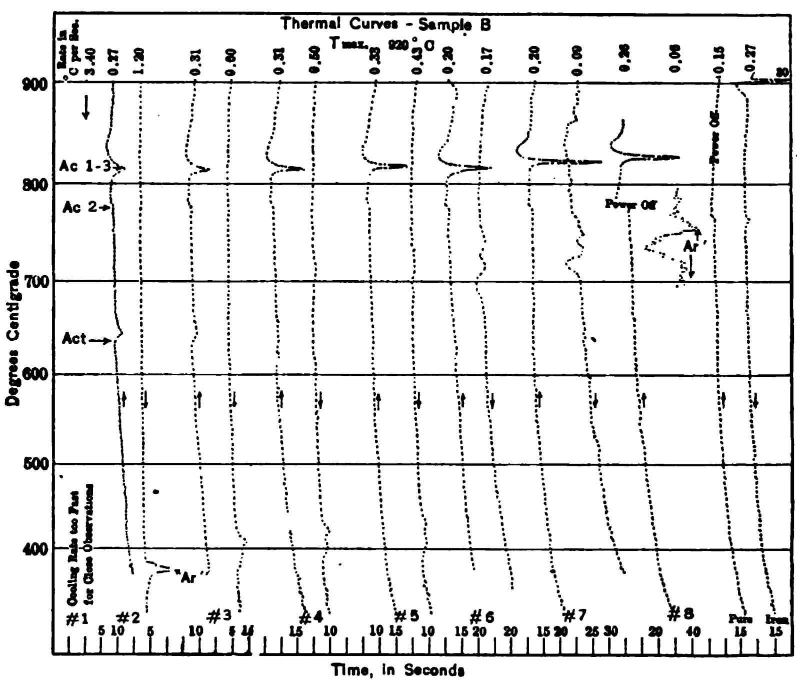
Thermal Curves - Sample B
Tmax. 920° C
Rate in °C per Sec.
Degrees Centigrade
Time, in Seconds
Ac 1-3
Ac 2
Act
Ar'
Power Off
Cooling Rate too Fast for Close Observations
#1
#2
#3
#4
#5
#6
#7
#8
Pure Iron

FIG. 2.

TABLE 1.—*Temperature Ranges of Transformations, in Degrees Centigrade*

Run	Rate of Heating	Ac′			Ac_3	Ac_{1-3}			Rate of Cooling	Ar′			Ar″			Maximum Temperature
		Beg.	Max.	End		Beg.	Max.	End		Beg.	Max.	End	Beg.	Max.	End	
Sample A																
1st..........	0.20	...	...	...	781	825	834	856	0.18	757	735	...	...	...	...	1050
2d..........	0.30	...	...	...	781	819	829	855	0.25	742	715	691	446	414	395	1125
3d..........	0.06	...	...	...	780	...	816	841	0.05	...	760	740	...	...	...	1110
4th..........	1.09	...	...	...	782	...	836	...	0.50	...	...	...	...	...	...	970
5th..........	0.25	...	...	...	751	804	816	847	0.28	755	...	670	422	396	357	925
6th..........	0.08	...	...	...	780	794	809	836	0.13	772	748	714	...	...	...	880
7th..........	0.06	...	...	...	...	809	817	841	0.04	776	766	734	...	...	...	870
8th..........	0.35	...	...	...	778	821	831	854	0.80	...	...	...	...	...	...	925
9th..........	0.33	...	...	...	...	809	819	847	0.71	...	...	...	401	385	318	925
Sample B																
1st..........		Rate of cooling too fast for close observations							3.40	...	...	...	...	...	...	920
2d..........	0.27	592	637	644	780	808	818	840	1.20	...	...	...	381	373	340	920
3d..........	0.31	578	634	644	780	809	816	832	0.60	748?	706	681	429	(409) (394)	371	920
4th..........	0.31	544	601	628	779	808	816	832	0.50	740	711	681	442	(423) (405)	387	920
5th..........	0.33	518	621?	637	778	813	818	835	0.43	748	(719) (694)	680	449	(430) (410)	392	920
6th..........	0.20	564	601?	628	778	807	818	829	0.17	759	(743) (719)	700	...	...	...	920
7th..........	0.20	...	...	...	778	814	824	835	0.09	775	(751) (736)	723	...	...	...	920
8th..........	0.26	...	...	...	...	821	829	842	0.06	770	756	738	...	...	...	920

The transformations, as designated on the curves of Figs. 1 and 2, are Ac_t, an evolution of heat on heating a sample previously cooled at a rate that gave Ar''; Ac_2, the magnetic transformation; Ac_{1-3}, the transformations Ac_1 and Ac_3 merged or nearly superimposed; Ar', the upper transformation of the split Ar transformations; and Ar'', the lower transformation. The temperature values of these transformations are collected in Table 1.

The appropriateness of the transformation notation Ac_{1-3} and Ac_t will be seen from the discussion of those transformations. Two values for the maximum transformation temperature indicate a double peak. In Fig. 3, the temperature values of Ac_{1-3}, Ar', and Ar'' given in Table 1 are plotted against rate of temperature change in degrees C. per second. No attempt is made to interpret the double peaks and lines representing Ar' and Ar'' in Fig. 3 are rather arbitrarily drawn through the higher values.

Effect of Cooling Rate

An inspection of the cooling curves of Figs. 1 and 2 shows that Ar' is the normal Ar_{3-2-1} of slow cooling rates, but that it gradually dies off in intensity with increasing rate. While Ar' is falling off in intensity,

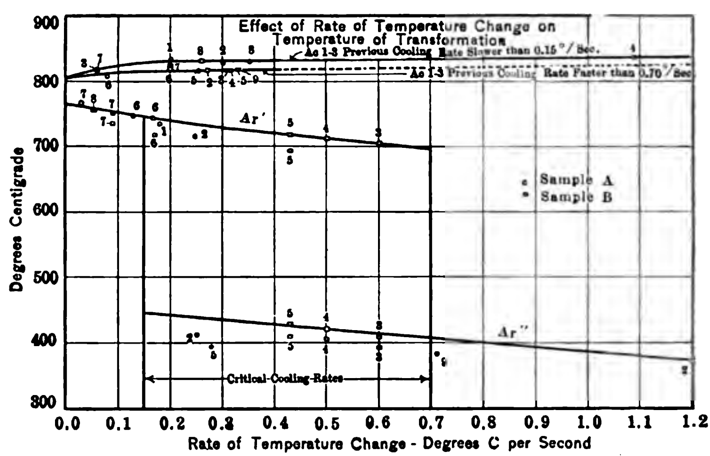

FIG. 3.

the transformation Ar'' comes into existence and gains in intensity, being a maximum for rates that do not show Ar'. This region over which both Ar' and Ar'' occur, as shown in Fig. 3, will be called the critical cooling range. Its limits were roughly determined as 0.15° and 0.70° C. per second, by plotting a measure of the transformation intensities obtained by a method to be described in a subsequent section, against rate and extending a straight line through the values back to zero.

The remarkable change in properties caused by this very slight change in rate is represented, when the same phenomenon is observed on varying the maximum temperature, by the considerable temperature variation of approximately 300° C. for some high-speed steels.[14] The fact that the split transformation occurs with a constant value of the maximum temperature shows that it is unnecessary to hypothecate a dissociation of the carbide (or carbides) to explain this phenomenon.

To establish the structural difference between the material cooled at a rate that gave Ar′ and one that gave Ar″ and the analogy to the

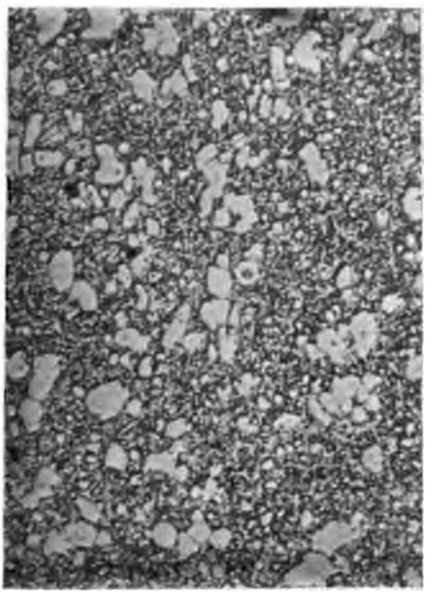

Fig. 4.

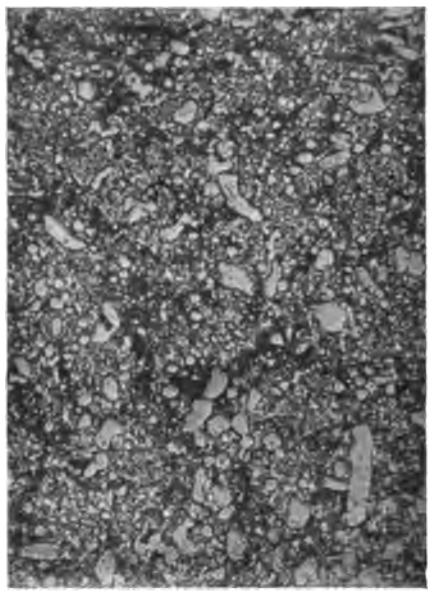

Fig. 5.

Fig. 4.—Cooling rate 0.01° C. per second, transformation Ar′.
Fig. 5.—Cooling rate 0.30° C. per second, transformation Ar′ and Ar″.

phenomena obtained by varying the maximum temperature for this steel, micrographs[15] were taken of samples cooled at several definite rates of cooling. The micrograph, Fig. 4, taken after cooling at a rate of 0.01° C. per second, Ar′ only occurring, shows an irregular mass of fine carbide particles corresponding to pearlite in carbon steels and distinct from the coarse particles of free carbide in a ferrite matrix. Figs. 5 and 6, micrographs taken of samples cooled at rates of 0.30° and 0.33° C. per second respectively, show characteristic black troostite patches on a background of martensite. With those cooling rates, the transformations Ar′ and

[14] Honda and Murakami, *Loc. cit.*
Carpenter, *Loc. cit.*

[15] Micrographs by H. S. Rawdon.

Ar″ were both obtained. Fig. 7, which is a micrograph of sample A following a cooling rate of 0.71° C. per second, shows a martensitic structure although the needle-like markings, characteristic of high-carbon steels, are only slightly evident. The conclusions to be drawn from this microscopic evidence are that troostite or a decomposition product forms with the transformation Ar′ and martensite with the transformation Ar″, precisely what obtains when the same transformations are observed in other alloy steels with varying maximum temperature.

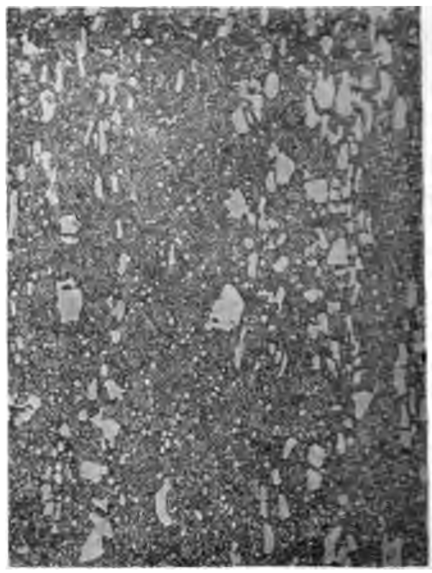

FIG. 6. FIG. 7.

ETCHED IN 2 PER CENT. HNO_3 IN ALCOHOL. × 750.

FIG. 6.—COOLING RATE 0.33° C. PER SECOND, TRANSFORMATION AR′ AND AR″.
FIG. 7.—COOLING RATE 0.71° C. PER SECOND, TRANSFORMATION AR″.

The radical structural difference between the material showing Ar′ and that showing Ar″ presumes a similar radical difference in the transformations Ar′ and Ar″. To demonstrate the possibility of this difference, the intensities of the transformations $Ac_{1\text{-}3}$, Ac_2, Ar′, and Ar″ have been estimated by means of a planimeter measuring the area of the positive departure of the thermal curves from the assumed neutral body curves through the respective transformation ranges. The results, given in Table 2, show a well marked loss in intensity of the sum of the areas of Ar′ and Ar″ at the cooling rate of 1.20° C. per second, which gives Ar″ above. On the assumption that Ar″ is no new transformation other than $Ar_{3,\ 2 \text{ or } 1}$, the conclusion is that some one or more of the transformations $Ar_{3,\ 2 \text{ and } 1}$ constituting Ar′ is suppressed.

TABLE 2.—*Areas of Thermal Curves, in Square Millimeters, Corresponding to Heat Effects of Transformations in Sample B*

Run	Ac_{1-3}	Ac_2	$Ac_{1-3}+Ac_2$	Cooling Rate, in Degrees per Second	Ar′	Ar″	Ar′+Ar″
1st	..	..	...	3.40			
2d	36	74	110	1.20	...	84	84
3d	40	66	106	0.60	26	72	98
4th	40	68	108	0.50	38	60	98
5th	64	64	128	0.43	56	48	104
6th	60	64	124	0.17	100	..	100
7th	72	72	144	0.09	120	..	120
8th	72	..	...	0.06	116	..	116
Average	..	68	120	....			

The preceding conclusion agrees with the generally accepted conception that martensite is a solid solution of cementite in some form of iron. This means that Ar′ is suppressed with the formation of martensite and further evidence is not wanting. The transformation intensities indicate that a heat effect of the magnitude of Ar′ is missing at Ar″. The work of Honda on the magnetic properties of tungsten steels, in a paper before the Iron and Steel Institute, however, shows that the carbide is retained in solution at Ar″ for the carbide in solution does not undergo the transformation A_0. The transformations Ac_t and Ac_{1-3} offer still further substantiation to which attention will be called in their discussion.

There still remains the possibility that one of the other transformations $Ar_{3 \text{ or } 2}$ is suppressed. This, however, is manifestly impossible, for A_3 and A_2 coincide when A_3 is depressed[16] below the normal temperature of A_2 and martensite is magnetic. The magnetic curves of Honda and Murakami[17] taken on a number of tungsten steels showing a split transformation with increasing maximum temperature, also indicate the occurrence of A_2 at Ar″.

The conclusion that must therefore be adopted is that Ar′ is suppressed with the formation of martensite, or that Ar″ constitutes the transformations Ar_3 and Ar_2.

TRANSFORMATIONS ON HEATING

The thermal curves of Figs. 1 and 2 show two transformations Ac_{1-3} and Ac_2 occurring uniformly within narrow temperature limits and a transformation Ac_t occurring only following certain cooling rates. The

[16] Kôtarô Honda and Hiromu Takagi: On the Cause of the Irreversibility of Nickel Steels. *Sci. Rep.* Tohoku Imp. Univ. (1917), **6**, 324.

[17] Honda and Murakami, *Loc. cit.*

identity of Ac_2 is established by its markedly characteristic shape and its uniform occurrence at about 780° C., which is in close proximity to its maximum, 768°, in pure iron. This phenomenon of Ac_1 occurring above Ac_2 in alloy steels is not new and has been well established by Moore[18] for a chromium steel. The transformation Ac_{1-3} hardly needs identification, though attention should be called to its sluggish ending, which indicates that the transformations concerned do not completely coincide. This is further illustrated by the change in area of the peak, which is evidently Ac_1 from the effect of previous cooling rate on its position, with the temperature of its occurrence.

The transformation Ac_t is indicated by an inflection to the left, which denotes an evolution of heat on the heating curve and occurs over a considerable temperature range. It is a maximum following cooling rates that give Ar″ alone, and loses in intensity following decreasing rates through the critical cooling range, becoming zero when Ar′ alone occurs. It is therefore roughly proportional in intensity to Ar″ or the amount of martensite present. By its analogy to tempering, the conclusion may be drawn that Ac_t represents the precipitation of the carbide in solution to form at first troostite and as it progresses the coarsening of the carbide.

This phenomenon of a heat evolution on heating steels that show Ar″ was observed by Carpenter[19] on differential thermal curves with which the maximum temperature was varied and connected with tempering.

The nature of Ac_t, a gradual building up of the heat evolution over a long temperature range, may throw some light on the spontaneous heat evolution and also the change in other physical properties of quenched steels, as observed by Hadfield and Brush,[20] by Matsushita,[21] and by Campbell.[22] The indications are that the transformation starts to a minute degree at very low temperatures, possibly at ordinary temperatures, particularly in carbon steels which temper at lower temperatures than alloy steels. The existence of Ac_t as an evolution of heat following cooling rates that give Ar″ is further confirmation of the suppression of Ar_1 with the formation of martensite.

It will be seen on examining Fig. 3 that practically all the temperature

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[18] Harold Moore: The A_2 Point in Chromium Steel. *Jnl.* Iron and Steel Inst. (No. I, 1910), **81**, 268–286.

[19] H. C. H. Carpenter: Types of Structures and the Critical Ranges on Heating and Cooling of High-Speed Tool Steels under Varying Thermal Treatment. *Jnl.* Iron and Steel Inst. (No. 1, 1905), **67**, 433–473.

[20] Charles F. Brush and Sir Robert A. Hadfield: Spontaneous Generation of Heat in Recently Hardened Steel. *Proc.* Royal Soc. of London (1917), **93**, 188–211.

[21] T. Matsushita: On the Slow Contraction of Hardened Carbon Steels. *Sci. Rep.* Tohoku Imp. Univ. (1918), **7**, 43–52.

[22] E. D. Campbell: Rate of Change at 100° C. and at Ordinary Temperatures in the Electrical Resistance of Hardened Steel. *Advance Paper, Jnl.* Iron and Steel Inst. (Sept., 1918).

values for the maximum of Ac_{1-3} lie on two smooth curves. The data of Table 1 shows that the runs which correspond to the numbers on the upper curve were obtained following cooling rates that gave Ar′ predominant and those on the lower curve following cooling rates that gave Ar″ predominant. The temperature interval, 10 to 15° C., between those two curves may therefore be attributed to the state of division of the carbide resulting from the previous heat treatment.

The phenomenon noted in the preceding paragraph offers still further substantiation of the suppression of Ar′ with the formation of martensite. It may be of interest to note that the curves of Fig. 3 drawn through the temperature values of Ac_{1-3} and Ar′ do not point toward a common equilibrium temperature Ae_1.

Summary

The results of previous investigation have been taken to show that with the occurrence of a split transformation on cooling alloy steels from increasingly higher temperatures: (1) that when the higher temperature transformation Ar′ is observed with low values of the maximum temperature, troostite or a decomposition product results, and (2) that when the lower temperature transformation Ar″ is observed with high values of maximum temperature, martensite is the resulting product. The present investigation has shown for a certain alloy steel that on varying the rate of cooling, the maximum temperature remaining constant, a strictly analogous phenomenon is observed, increasing rate of cooling having the same effect as increasing the maximum temperature. Conclusions are drawn to the effect that:

1. The transformation Ar′ consists of the transformations Ar_3, Ar_2, and Ar_1.

2. The transformation Ar″ consists of the transformations Ar_3 and Ar_2.

3. The transformation Ar_1, suppressed when Ar″ is observed, occurs on heating as Ac_t with an evolution of heat and the formation of troostite or a coarser condition of the carbide.

4. The maximum of the transformation Ac_{1-3} occurs at a higher temperature when the previous cooling rate gave Ar′ than when it gave Ar″.

The author desires to express his indebtedness to Mr. H. S. Rawdon for the micrographic work and to Miss P. L. Thompson for her skilful assistance in preparing the experimental data.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Volatilization of Cuprous Chloride on Melting Copper Containing Chlorine

BY S. SKOWRONSKI,* B. S., AND K. W. MCCOMAS,† B. S., PERTH AMBOY, N. J.

(New York Meeting, February, 1919)

Contents

Purpose of Investigation

Since cuprous chloride melts at 418° C., boils at 954° C. to 1032° C.,[1] and is known to be volatile at a much lower temperature, the presence of chlorine in any form in or on copper to be melted has always been looked upon by copper refiners as a possible source of serious copper loss. Although this fact has been known for some time, the copper literature contains little or no information regarding it and the field seems never to have been properly investigated from a metallurgical standpoint.

According to Greenawalt,[2] cupric chloride, $CuCl_2$, when ignited gives cuprous chloride; therefore cuprous chloride is always formed when copper enters into reaction with chlorine at a high temperature. Cuprous chloride melts somewhat below a dull red heat, and does not volatilize in closed vessels, even if strongly heated, but if heated in the air it goes off as a white vapor. Hofman[3] gives the melting point of cuprous chloride

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† Chief Chemist, Raritan Copper Works.

[1] Van Nostrand's "Chemical Annual," 162. New York, 1918. D. Van Nostrand Co.

[2] W. E. Greenawalt: "Hydrometallurgy of Copper," 163. New York, 1912. McGraw-Hill Book Co.

[3] H. O. Hofman: "Metallurgy of Copper," 57. New York, 1914. McGraw-Hill Book Co.

as 434° C. and states that it is volatile at 340° C. Prescott and Johnson[4] quote Weltzien,[5] that if dry hydrochloric-acid gas be passed over heated copper, cuprous chloride is formed with the evolution of hydrogen.

The reactions of cupric chloride and cuprous chloride at low temperatures have been carefully studied, since they form the basis of the Deacon process for the recovery of chlorine. The reactions involved in that process are as follows:

$$2CuCl_2 \rightarrow Cu_2Cl_2 + Cl_2$$
$$Cu_2Cl_2 + O_2 \rightarrow 2CuO + Cl_2$$
$$2CuO + 4HCl \rightarrow 2CuCl_2 + 2H_2O$$

These reactions are all reversible and large excesses of hydrochloric acid and oxygen are needed to make the reactions occur in the proper direction. In melting copper cathodes containing chlorides, however, the reverse is the case and the proportion of copper to chlorine is so large that, even if cuprous chloride did decompose with the formation of the oxide, the chlorine liberated should at once reform cuprous chloride because of the large excess of copper present.

Samples of flue dust taken from the outgoing gases at the stack of the refining furnaces melting copper cathodes containing such a small trace of chlorine as to be undeterminable have shown that 15 per cent. of the total copper loss at that point was present as cuprous chloride. While the percentage loss was large, the average actual loss was small, amounting to 40 lb. (18 kg.) of cuprous chloride per charge or an equivalent of 0.10 lb. (0.045 kg.) of copper per ton of copper melted. This loss was not large enough to warrant the installation of a costly recovery system, but emphasized the facts of a metallurgical copper loss due to chlorides and the possibilities of much larger stack losses on melting copper containing determinable quantities of chlorine.

On melting copper known to contain chlorine, the fumes given off while charging the furnace have at times so inconvenienced the furnace men as to cause improper charging, materially cutting down the size of the charge and causing labor dissatisfaction. Fumes are also noticed in considerable amount when skimming a furnace charge containing a high percentage of chlorine, and occasionally the fumes from the furnaces are so dense and penetrating as to render it necessary for the workmen to vacate the casting building.

Furnace tests conducted some years ago on melting cement copper produced by the Henderson & Longmaid process, and containing 0.50 per cent. of chlorine, showed a large loss of copper by volatilization as cuprous chloride. The tests, however, were not quantitative and no data

[4] A. B. Prescott and O. C. Johnson: "Qualitative Analysis," 105. New York, 1916. D. Van Nostrand Co.

[5] M. C. Weltzien: *Ann. de Chim. et Phys.* (1865) [4], **6**, 487.

were obtained as to the actual furnace losses. With the recent development of the hydro-electric treatment of copper ores, the cathode tonnage of which is now considerable and continually increasing, the problem of the volatilization of cuprous chloride, if present on the cathodes, is very important owing to the large factors involved. If all the chlorine present on the cathode sheets is considered volatile as cuprous chloride, for every pound of chlorine present on or in the cathodes, a theoretical equivalent of 1.79 lb. of copper will be volatilized during the melting, or an equivalent loss of 3.6 lb. of copper per ton of material for each 0.1 per cent. of chlorine present in the cathodes. It can thus be seen that, where large tonnages are involved, a serious metal loss may result on melting cathode sheets containing but a small percentage of chlorine. In the hydro-electric treatment of copper ores, the presence of chlorides in any form, either in the ore to be leached or in the water used in leaching, will result, on electrolysis, in a deposition of cuprous chloride on the cathodes unless the chlorine is previously removed.

In laboratory experiments, electrolyzing copper sulfate solution containing sodium chloride and using soluble anodes, a white deposit was obtained on the anode, which turned light green in color on drying at 90° C. and had the following composition: Copper 61.84 per cent., chlorine 33.60 per cent.; factor of copper to chlorine, 1.84. On standing 24 hr., the color of the compound changed to a much darker green and had considerably hydrated, as shown by the following analysis: Copper 50.00 per cent., chlorine 26.96 per cent.; factor of copper to chlorine, 1.85.

It is evident that the white deposit was cuprous chloride, which readily became hydrated on 24 hr. standing. A comparison of the two factors shows that there was no oxidation to cupric chloride on standing 24 hr. Duplicating the experiment using lead anodes, the cuprous chloride did not form on the anode but permeated the cathode deposit to such an extent that it could not be readily separated from the deposited copper.

Indirectly, it is easy to prove that a certain percentage of the copper present as cuprous chloride on cathodes is volatilized on melting. Crucible tests made by melting cathode copper containing cuprous chloride always show a copper loss as compared with melting an equivalent weight of cathodes free from chlorides, but the problem is generally complicated by the presence of oxides and moisture on the hydro-electric cathodes and no definite conclusions can be drawn as to just how much copper is volatilized as compared with the original chlorine contents of the cathodes.

The direct method of investigation followed in these experiments consisted in melting 25 gm. of copper, containing chlorides, in an alundum boat and condensing the cuprous chloride volatilized. This cuprous chloride could not be weighed, but was dissolved in water and nitric acid and the copper and chlorine determined by the usual analytic methods.

DETAILS OF EXPERIMENT

The accompanying illustration shows the apparatus used in these experiments. The copper was weighed and transferred to alundum boats which, in turn, were placed in a 1-in. fused silica tube and the copper melted or heated under a current of carbon dioxide, air, or furnace gases. The carbon dioxide was generated by the action of hydrochloric acid on calcium carbonate and was purified by passing successively through solutions of sulfuric acid, silver nitrate, and sulfuric acid. A No. 17 Fletcher tube furnace with blast was used. No trouble was experienced in melting copper satisfactorily.

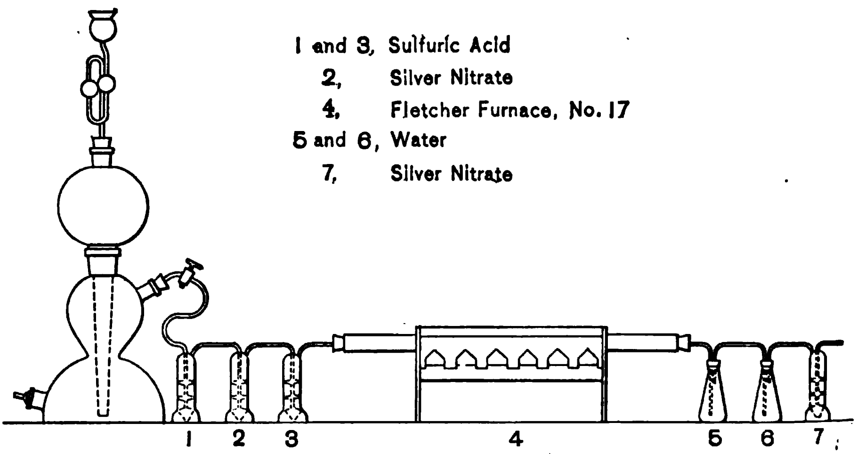

FIG. 1.—APPARATUS USED IN EXPERIMENTS.

The volatilized cuprous chloride condensed partly in the cold end of the silica tube and the remainder was caught by passing the gases successively through two Erlenmeyer flasks containing water, and a Bowen bulb tube containing an acid solution of silver nitrate. After the copper had melted, or had been heated for the specified length of time, the furnace was allowed to cool, the alundum boat removed, and the copper analyzed for any chlorine that was not driven off. The silica tube was carefully washed with water and nitric acid until tests showed the washings to be free from both copper and chlorine. The contents of the Erlenmeyer flasks and Bowen bulb, as well as the washings of all the glass connections, were added to the solution obtained from the silica tube and the total copper and chlorine present determined. The chlorine and copper determinations were made by the same analyst under exactly the same conditions for all the experiments and working independently from the experimenter.

The first series of experiments was conducted while melting hydro-electric copper drillings under a neutral gas, to avoid any possible wrong conclusions, caused by the interference of either an oxidizing or reducing atmosphere. As these experiments were conducted not only to study the volatilization of cuprous chloride, but to arrive at some definite conclusion as to the furnace loss in melting hydro-electric cathode sheets, containing chlorine, under present refining conditions, two other series of experiments were conducted, one aspirating air over the sample while melting, and the other aspirating gases collected from a refining furnace during the melting-down period.

Experiment Series No. 1

Melting Copper Containing Chlorine Under Carbon Dioxide

Owing to the possibility of a very finely divided copper rain being formed as the copper was melting, blanks were run using cast copper, free from chlorine. The heating and melting of this copper and the cleaning of the silica tube and flasks and solution bulbs were conducted in identically the same manner as with the regular experiments. The blank tests were made by melting 25 gm. of drillings of cast copper that was 99.95 per cent. pure and contained no chlorine; the time of heating and melting was 1 hr. The results are given in Table 1. The average loss of copper is small and well within the limit of experimental error and has no influence on the final results and summary.

Table 1.—*Melting Drillings of Cast Copper*

Test No.	Weight of Copper in Tube and Bulbs, Gram	Weight of Chlorine in Tube and Bulbs, Gram
1	0.0003	nil
2	0.0002	nil
3	0.0004	nil
Average................	0.0003	nil

Melting Hydro-electric Cathodes

A carefully prepared representative sample of hydro-electric cathodes was used in this experiment. Analyses showed it to contain 99.58 per cent. copper and 0.226 per cent. chlorine; 25 gm. were used for all tests; and the equivalent weight of chlorine in each test was 0.0565 gm. The time of heating and melting was 1 hr.; 14 tests were made.

The results are given in Table 2. Column 2 gives the weight of chlorine left in the copper after melting. With the exception of test No. 7, this amount is practically negligible. Columns 3 and 4 give the weights of the chlorine and copper that volatilized during the experiment and were determined by washing out the condensed cuprous chloride from tube and flasks. Column 5 shows the ratio of volatile copper to volatile chlorine; that is, simply the ratio of column 4 to column 3. The average factor obtained, 1.76 parts of volatile copper to 1 part of volatile chlorine, is remarkably close to 1.79, the theoretical factor of

TABLE 2.—*Volatilization of Copper and Chlorine on Melting Cathodes*

Test No. 1	Weight of Chlorine Remaining in Melted Copper, Gram 2	Weight of Volatile Chlorine, Gram 3	Weight of Volatile Copper, Gram 4	Factor Volatile Copper to Volatile Chlorine 5	Factor Volatile Copper to Chlorine Contents of Sample 6
1	0.0006	0.0496	0.0820	1.65	1.47
2	0.0006	0.0538	0.0970	1.81	1.74
3	0.0002	0.0497	0.0831	1.67	1.48
4	0.0004	0.0523	0.1011	1.93	1.80
5	0.0009	0.0523	0.0862	1.65	1.55
6	0.0004	0.0546	0.0871	1.60	1.55
7	0.0021	0.0493	0.0861	1.75	1.58
8	0.0003	0.0462	0.0886	1.92	1.58
9	0.0003	0.0515	0.0950	1.85	1.69
10	0.0004	0.0558	0.0970	1.74	1.73
11	0.0004	0.0513	0.0906	1.77	1.61
12	0.0003	0.0516	0.0877	1.70	1.56
13	nil	0.0493	0.0873	1.77	1.55
14	0.0003	0.0575	0.1019	1.77	1.81
Average....	0.0005	0.0518	0.0908	1.76	1.62

copper to chlorine in cuprous chloride, and proves that the chlorine present in the cathodes is volatile as cuprous chloride. Column 6 is the ratio between the copper volatilized, as shown in column 4, to the chlorine contents of the original drillings as shown by the analysis, 0.226 per cent. chlorine or 0.0565 gm. chlorine present in the experiment; due allowance is made for the chlorine left in the melted copper. The average factor 1.62 is based altogether on the analysis of the sample and does not take into account any variation of the chlorine contents in the sample itself. Individual analyses of the same sample show a variation as great as 0.02 per cent. chlorine, which would account for the difference in the two factors.

Tests on Heating Hydro-electric Cathodes

In crucible melting tests, it was found that soon after the crucibles containing hydro-electric cathode copper had been placed in the furnace, heavy white fumes were driven off. This continued for some time but before the crucible contents had actually melted these fumes had disappeared, indicating that most of the cuprous chloride was volatilized before the melting temperature of the copper had been reached. In order to learn just what effect heating of the cathodes without melting would have, the following test was made. This experiment was conducted in identically the same manner as the preceding one, except that the copper was not melted, but the drillings were heated at a red heat for 2 hr. The copper and chlorine contents, etc., of the sample were the same as in the preceding experiment. The results of the three tests

TABLE 3.—*Results of Heating Hydro-electric Cathodes*

Test No. 1	Weight of Chlorine Remaining in Copper, Gram 2	Weight of Volatile Chlorine, Gram. 3	Weight of Volatile Copper, Gram 4	Factor Volatile Copper to Volatile Chlorine 5	Factor Volatile Copper to Chlorine Contents of Sample 6
1	0.0087	0.0487	0.0834	1.71	1.74
2	0.0061	0.0455	0.0824	1.81	1.64
3	0.0090	0.0465	0.0823	1.77	1.73
Average....	0.0079	0.0469	0.0827	1.76	1.70

check closely with those obtained by melting the cathode drillings and again prove the volatilization of copper as cuprous chloride. Column 6, of Table 3, allows for the cuprous chloride remaining in the copper after heating; it is the ratio of the volatile copper to the chlorine contents of the cathodes by analysis, less the chlorine remaining in the copper, as shown in column 2. This factor, based on the analysis of the original drillings, is 1.70 against a factor of 1.76 obtained by comparing the actual volatile copper and volatile chlorine.

Melting Drillings of Copper Mixed with Sodium Chloride

It occasionally happens that the chlorine in the cathodes is not present as cuprous chloride, but may be there as sodium chloride. In order to study the effect of sodium chloride on copper, cast copper, 99.95 per cent. pure, free from chlorine was mixed with varying amounts of salt and melted as in the preceding experiments. The salt contains 58.48 per cent. chlorine.

TABLE 4.—*Melting Copper Drillings with Addition of Salt*

Test No.	Weight of Salt Added, Gram	Equivalent of Chlorine Added, Gram	Equivalent of Chlorine in Copper, Per Cent.	Weight of Copper Volatilized, Gram	Factor Volatile Copper to Chlorine Added	Percentage of Chlorine Volatilized as Cuprous Chloride
1	0.5000	0.2924	1.169	0.3259	1.12	62.6
2	0.2500	0.1462	0.584	0.1957	1.34	74.9
3	0.1000	0.0585	0.234	0.1060	1.81	100.0

The results of these tests, given in Table 4, show that the chlorine does not necessarily have to be in combination with the copper to cause volatilization of copper while melting. With an excess of sodium chloride, as in tests 1 and 2, some of the chlorine was volatilized as sodium chloride; but with the addition of small amounts of sodium chloride, approximating the chlorine contents of hydro-electric copper, as in test 3, the chlorine was quantitatively converted and volatilized as cuprous chloride.

Melting Cast Copper Drillings Mixed With Cupric Chloride

Owing to the possibility of the cuprous chloride on the cathodes becoming partly oxidized to the cupric condition on long standing, tests were made by mixing cast copper with cupric chloride and melting the copper as in previous experiments. The cupric chloride contained 37.18 per cent. copper and 41.3 per cent. chlorine; the factor of copper to chlorine was 0.9. While 0.0929 gm. of copper was added as cupric chloride,

TABLE 5.—*Melting Copper Drillings Mixed with Cupric Chloride*

Test No.	Amount of Cupric Chloride Added, Gram	Amount of Copper as Cupric Chloride, Gram	Amount of Chlorine Volatilized, Gram	Amount of Copper Volatilized, Gram	Ratio Volatile Copper to Volatile Chlorine
1	0.250	0.0929	0.0962	0.1742	1.82
2	0.250	0.0929	0.0936	0.1536	1.64
Average....	0.250	0.0929	0.0949	0.1639	1.73

on melting the copper 0.1639 gm. of copper was volatilized with a copper to chlorine factor of 1.73, thus showing that on melting copper containing cupric chloride, the cupric chloride becomes reduced to cuprous chloride and is volatilized as such. Since cupric chloride decomposes on heating to cuprous chloride and chlorine, the reaction must take place in two stages.

$$2CuCl_2 + \text{heat} \rightarrow Cu_2Cl_2 + Cl_2$$
$$Cl_2 + 2Cu \rightarrow Cu_2Cl_2$$

Experiment Series No. 2

Melting Hydro-electric Cathode Copper Drilling Under Air

The second series of experiments was made by aspirating air over the copper drillings while melting, thus substituting an oxidizing atmosphere for the neutral atmosphere of the former experiment. The same sample was used as in former experiments, the assay showing 99.58 per cent. copper and 0.226 per cent. chlorine. The time for heating and melting was ½ hr. The time of heating the drillings had to be shortened, preliminary tests showing that heating the drillings slowly resulted in excessive oxidation of the copper, which prevented the drillings from melting, no matter how much heat was applied. Consequently, a high heat was first applied without any preliminary warming up, in order to melt the copper before the drillings became excessively oxidized. Following this procedure, no difficulty was encountered. The results of the tests are given in Table 6.

Table 6.—*Volatilization of Copper and Chlorine on Melting Cathode Drillings Under Air*

Test No. 1	Chlorine Remaining in Melted Copper, Gram 2	Volatile Chlorine, Gram 3	Volatile Copper, Gram 4	Factor Volatile Copper to Volatile Chlorine 5	Factor Volatile Copper to Chlorine Contents of Sample 6
1	0.0003	0.0506	0.0880	1.74	1.57
2	0.0005	0.0472	0.0865	1.83	1.54
3	0.0005	0.0607	0.0967	1.59	1.73
4	0.0010	0.0565	0.0920	1.63	1.66
5	0.0005	0.0573	0.1009	1.76	1.80
6	0.0005	0.0560	0.0901	1.61	1.61
Average....	0.0006	0.0547	0.0924	1.69	1.65

Albert M. Smoot, of Ledoux & Co., carrying out an independent investigation on the same sample along similar lines, called attention to the fact of a possible hydrolysis of cuprous chloride and consequent formation of copper oxide should moisture be present in the gases passing over the copper. In order to test this theory, tests 1 and 2 were made with air saturated with water vapor; tests 3 and 4 with dry air; while in tests 5 and 6 the air was neither moistened nor dessicated and represented atmospheric conditions. From Table 6, the average factor of these tests with wet air is 1.56; with dry air, 1.70; and with air at atmospheric conditions, 1.70. These results would tend to prove Mr. Smoot's theory that wet gases would somewhat reduce the volatilization of cuprous chloride. However, furnace gases are neither saturated with water vapor nor are

they dessicated and an average of the six tests should be a fair average of furnace losses allowing for any possible moisture correction.

The factors found agree with those obtained in the former experiments, and show that even if cuprous chloride is oxidized and decomposed the chlorine thus liberated reunites with the copper owing to the mass of the copper present.

Experiment Series No. 3

Melting Hydro-electric Cathode Drillings Under Furnace Gases

In order more nearly to approximate actual furnace conditions, furnace gases were collected from refining furnaces during the melting-down period, and tests made on hydro-electric cathode drillings in identically the same manner as in former experiments, aspirating a steady stream of the furnace gases over the drillings while melting. The gas analyses are given in Table 7; the results of the tests, in Table 8.

Table 7.—*Analyses of Furnace Gases*

Test No.	CO_2 Per Cent.	O Per Cent.	CO Per Cent.	N Per Cent.
1	10.4	8.2	nil	81.4
2	14.8	2.4	1.0	81.8
3	13.6	5.0	nil	81.4
4	10.4	8.2	nil	81.4
5	15.4	2.8	0.2	81.6
6	11.4	6.2	nil	82.4

Table 8.—*Volatilization of Copper and Chlorine on Melting Cathodes Under Furnace Gases*

Test No. 1	Amount of Chlorine Remaining in Melted Copper, Gram 2	Amount of Volatile Chlorine, Gram 3	Amount of Volatile Copper, Gram 4	Factor Volatile Copper to Volatile Chlorine 5	Factor Volatile Copper to Chlorine Contents of Sample 6
1	0.0007	0.0479	0.0809	1.69	1.45
2	0.0004	0.0492	0.0842	1.71	1.50
3	0.0003	0.0584	0.1029	1.76	1.83
4	0.0005	0.0588	0.0959	1.63	1.71
5	0.0009	0.0539	0.0861	1.60	1.55
6	0.0008	0.0540	0.0858	1.59	1.54
Average....	0.0006	0.0537	0.0893	1.66	1.60

As in the preceding experiments, tests 1 and 2 were made with the gases saturated with water vapor; tests 3 and 4 with dried gases. In tests 5 and 6, while the gases were neither moistened nor dessicated they

were collected from the furnaces over water and were displaced during the experiment by water, so that the gases used contained more water vapor than under actual furnace condition. From Table 8 the average factor of these tests with wet gases is 1.48; dry gases, 1.77; gases as collected, 1.55.

These results again tend to prove Mr. Smoot's hydrolysis theory. The presence of water vapor in the gases seems to have more effect on the volatilization of cuprous chloride than the composition of gases passed over the copper while melting. The average of the six tests made under the three different conditions should give a fair average of furnace losses, allowing for any possible moisture correction; possibly a little low, because the gases in tests 5 and 6 contain more water vapor than is actually present in the furnace gases.

Summary

Experiments in melting drillings of cathode copper containing cuprous chloride, and analyzing the resulting volatile copper and chlorine, resulted in the following series of factors:

Factor Volatile Copper to Volatile Chlorine Based on Actual Determination of Volatile Products

Melting under carbon dioxide (14 tests)	1.76
Melting under air (6 tests)	1.69
Melting under furnace gases (6 tests)	1.66

Factor Volatile Copper to the Actual Chlorine Contents of Sample

Melting under carbon dioxide	1.62
Melting under air	1.65
Melting under furnace gases	1.60

Considering that the theoretical factor of copper to chlorine in cuprous chloride is 1.79, these experiments prove that the volatilization of cuprous chloride on melting cathode copper takes place almost in its molecular ratio, and that under present copper refining practice any cuprous chloride present in or on the cathode can be considered, for all practical purposes, as completely volatilized on melting, and may be the cause of a serious metallurgical loss of copper.

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

A Volute Aging Break

BY HENRY M. HOWE AND EDWARD C. GROESBECK, BEDFORD HILLS, N. Y.

(New York Meeting, February, 1919)

(A Contribution from Green Peace Laboratory)

FIG. 1 shows a volute aging break which developed spontaneously in a hardened and tempered steel helmet between 19 and 38 days after it had been tested ballistically.

A similar break, shown in Fig. 2, developed spontaneously in a similar helmet about 40 days after the ballistic testing. In this case the rupture occurred abruptly and with a loud report. The path of rupture in this second case, though much the less regular, is the more interesting of the

FIG. 1.

FIG. 2.

two, in that it is an approximation to two parallel volutes centered at the point of impact of the projectile, just below *D*. Several weeks later, after the photograph for Fig. 1 was taken, a similar doubling of the volute crack occurred in this helmet, starting from the end of the eye-lash crack near *A* and spreading thence to the left contra-clockwise for about ½ in.

The negatives from which these pictures are made have not been touched up in any way, save writing the letters on them.

In both cases the trajectory of the bullet was normal to the initial surface at the point of impact, and in both the helmet passed the ballistic

test without detectable cracking, under a velocity of impact not far below that which usually causes perforation. The initial surface itself was very nearly spherical throughout the region covered by the break.

In the early days of making armor-piercing shells, spontaneous and violent aging rupture was so common that the shells, after hardening, used to be stored for a considerable length of time in a room to which nobody was admitted.

Since the foregoing was written several additional volute breaks have been noticed, one at the opposite end of the helmet shown in Fig. 1, and one in another helmet. This last is at least as regular as that shown in Fig. 1.

These later cracks occurred about three months after the ballistic testing ended. About two weeks later the attention of one of us was arrested by a succession of faint cracklings proceeding from a pile of tested helmets.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

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Microstructural Features of Flaky Steel*

BY HENRY S. RAWDON,† WASHINGTON, D. C.

Introduction

One of the most vital problems in the manufacture of steel at present is the occurrence of the defects that have been popularly termed "snow flakes," "flakes," or "scabs." Particularly is this the problem of many manufacturers who during the past 2 yr., have undertaken large-scale production for the first time. A study of the microstructure of such defective material throws considerable light upon the nature of these defects and is essential before measures may be taken for the elimination of the defects. Flakes do not appear to be found in the plain carbon steels; they have been found, however, in abundance in some of the simple alloy steels that are being used in such vast quantities; viz., nickel steel of the approximate composition, 0.40 carbon and 3.5 per cent. nickel, and in the chrome-nickel type. The present article summarizes the characteristic features of defective steel of the flaky type as they have been found by laboratory study of numerous specimens, and it aims to show the conditions within the metal that are favorable to the occurrence of this type of defect without entering into the details of mill practice (size of ingot, design of molds, rate of cooling, distribution of cooling stresses, etc.), all of which conditions appear to play a role in the production of these defects.

Macrostructure

To one familar with flaky steel, the appearance of "snow-flakes" is unmistakable and is not to be confused with other types of defects. Figs. 1 to 6 show the appearance of fractures of steel showing this type of defect; the white silvery area, which always has the appearance of being of a very coarsely crystalline structure, in the specimen stands out in bold contrast to the darker background and readily justifies the use of the term "snow-flakes." Fig. 1 shows the appearance of the faces of the two halves of a nickel-steel forging that has been split to show

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* Report of research under the Auspices of the National Research Council.

† Associate Physicist (Metallography), U. S. Bureau of Standards.

the interior flakes. Fig. 2 is a nickel-steel bar (carbon 0.40 per cent., nickel 3.62 per cent., chromium 0.35 per cent. not intentionally added) intended for use in the manufacture of a propeller shaft.

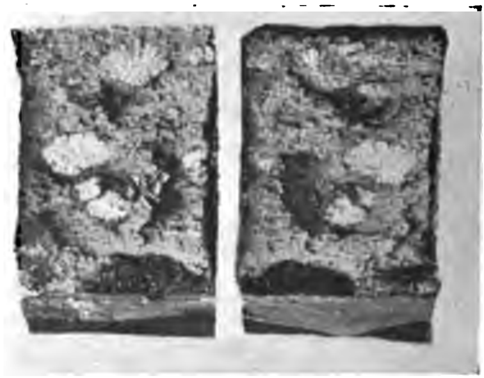


FIG. 1.—NICKEL-STEEL FORGING SPLIT TO REVEAL FLAKES. × 1.

In the examination of material for the detection of flakes, the specimens are often nicked and broken under impact; unless the steel has a very

FIG. 2.—CHROME-NICKEL STEEL BAR, C, 0.40; NI, 3.62; CR, 0.35, THAT HAS BEEN NICKED AND BROKEN TO SHOW FLAKES. × 1.

fine grain the contrast between the coarse face of the flake and the surrounding metal may not be very marked. The best procedure is to refine the grain by properly hardening the piece before breaking. The

flakes will then appear as coarsely crystalline areas surrounded by the smooth porcelain-like fracture of the surrounding sound metal. Fig. 3 shows such a fracture of the material of Fig. 2 after so hardening. The

FIG. 3.—MATERIAL SIMILAR TO THAT OF FIG. 2, THAT HAS BEEN HARDENED AND THEN BROKEN. × 1.

area designated as the flake always has an appearance suggesting a coarsely crystalline structure. The crystals, however, are markedly

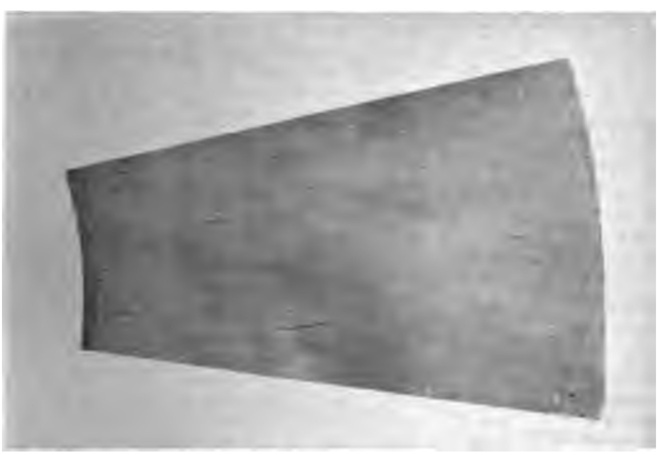


FIG. 4.—SECTION OF DISK CUT FROM NICKEL-STEEL GUN FORGING, C, 0.38, CR, 0.20, NI, 2.92, POLISHED TO SHOW FLAKES. × 1.

different from those of the remainder of the fracture—no sparkling cleavage planes are to be found, instead the corners and edges of the crystals are rounded and smoothed and the surfaces often have a very

fine matt finish. They have the appearance of crystals that were squeezed together while soft and plastic and yet failed to adhere firmly to one another. The same type of break is obtained by fracturing a bar

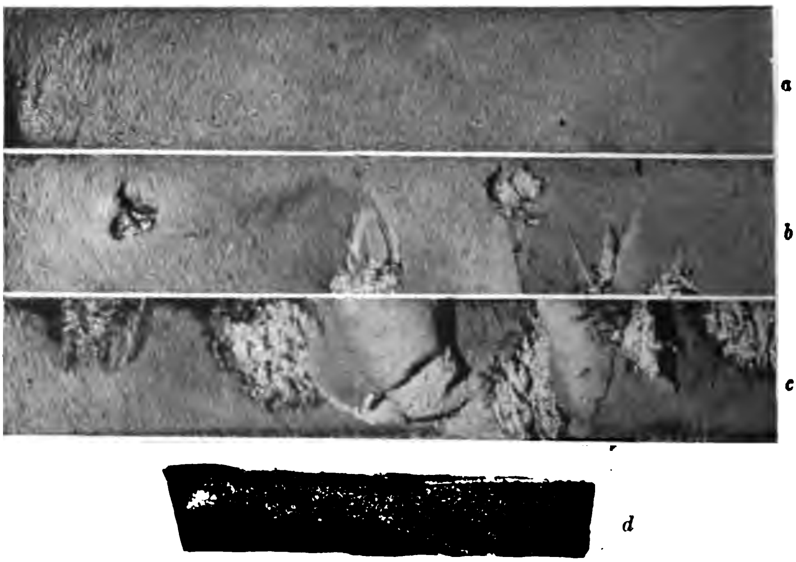


FIG. 5.—*a*, BAR CUT TRANSVERSELY FROM NICKEL-STEEL DISK, SIMILAR TO THAT OF FIG. 4, BROKEN BY ALTERNATING STRESSES; MATERIAL WAS SOUND, NO FLAKES WERE REVEALED. × 2. *b*. SIMILAR MATERIAL TO *a*; SEVERAL FLAKES WERE REVEALED WHEN BROKEN BY ALTERNATING STRESSES. × 2. *c*. SIMILAR MATERIAL TO *a* AND *b*; METAL CONTAINS NUMEROUS LARGE FLAKES. SOUND METAL FORMS SMOOTH PORCELAIN FRACTURE, FLAKES HAVE USUAL COARSELY CRYSTALLINE APPEARANCE. × 2. *d*. SPECIMEN SIMILAR TO *b* BROKEN BY IMPACT; FLAKES ARE RELATIVELY INCONSPICUOUS, COMPARED WITH THOSE IN *b* AND *c*. × 1.

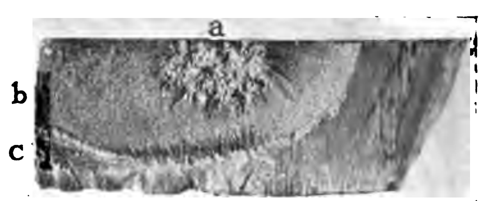


FIG. 6.—MATERIAL OF FIG. 5*c*; THIS FLAKE WAS LOCATED BACK OF PLANE OF FRACTURE AND WAS VERY SLIGHTLY OPENED UP BY ACTION OF ALTERNATING STRESSES; IT WAS THEN BROKEN OPEN BY IMPACT. × 2. *a*, COARSE FRACTURE DUE TO FLAKE. *b*, SMOOTH PORCELAIN DETAIL FRACTURE. *c*, COARSE CRYSTALLINE BREAK DUE TO IMPACT.

by the action of alternating or by repeated stresses. Figs. 5 and 6 show the appearance of a sound specimen of nickel steel, carbon 0.41, chromium 0.106, nickel 2.85, and two flaky bars of similar material,

carbon 0.37, chromium 0.01, nickel 2.83, fractured by alternating stresses. The flakes revealed in this manner are much more striking in appearance than when the same specimen is broken transversely by impact. Fig. 5d shows one of these specimens broken in this latter manner. That the area of the flake is a nucleus for the starting of the

FIG. 7. FIG. 8.

FIG. 7.—RADIOGRAPH OF BAR OF SOUND NICKEL-STEEL 3/8 IN. THICK, SAME MATERIAL AS FIG. 5a.

FIG. 8.—RADIOGRAPH OF SIMILAR BAR OF FLAKY NICKEL-STEEL, SAME MATERIAL AS FIG. 5c; EACH WHITE TRANSVERSE LINE MARKS LOCATION OF A FLAKE.

detail fracture that produces the fine porcelain-like break is illustrated in Fig. 6. This represents a flake located somewhat back of the plane on which the break finally took place in the specimen, Fig. 5c, broken by alternating stresses. After the completion of the test, the metal here was opened by sawing in from the sides and then breaking by a hammer

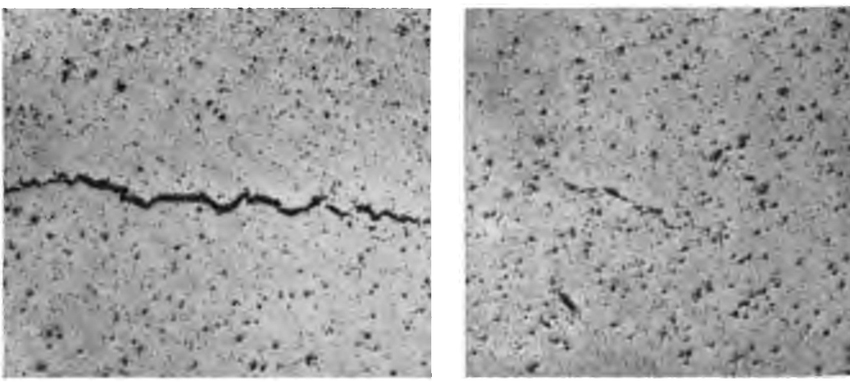
FIG. 9.—CROSS-SECTION OF A BAR OF FIG. 8, BROKEN ALONG THE LINE x–x IN RADIOGRAPH. × 2.

blow. The fracture shows three portions: the coarse crystalline flake, the smooth detail break surrounding this, and the outer crystalline portion broken by impact. Without doubt this flake acted as a center from which the detail break proceeded outward on all sides.

The flakes are often found to have a rather definite and symmetrical

arrangement in the piece in which they occur. Fig. 4 shows a sector of a cross-section of a gun forging, carbon 0.38, chromium 0.20, nickel 2.92 in which the flakes were very abundant. The radial arrangement is very evident. The same symmetry has been noted in much smaller pieces, that is 4 and 5-in. (10 and 12 cm.) billets of chrome-nickel steel.

The examination by means of X rays of steel suspected of being flaky is of instructive interest and throws some additional light on the nature of the defect. Figs. 7 and 8 show radiographs of a sound $\frac{3}{8}$-in. (9 mm.) bar of steel, carbon 0.41, chromium 0.106, nickel 2.85, and a specimen of very similar composition, carbon 0.37, chromium 0.010, nickel 2.83, but suspected of containing flakes. These bars were cut transversely out of finished gun forgings of the approximate composition



a *b*

FIG. 10.—SAME MATERIAL AS FIG. 4, ETCHED WITH 2 PER CENT. COPPER-AMMONIUM CHLORIDE SOLUTION. × 15. *a*, LARGE FLAKE; WHICH APPEARS TO BEAR NO RELATION TO SLAG INCLUSIONS. *b*, SMALL FLAKE; INCLUSIONS THAT AIDED IN FORMATION ARE PLAINLY SEEN.

given. Each white transverse line in the second radiograph, Fig. 8, indicates the location of a flake as was shown by sawing in from the sides of the line $x - x$ and breaking the specimen along the line. The large flake shown in Fig. 9 was revealed in this manner. The white lines marking the location of the flakes indicate discontinuities in the metal along these lines. They are due to the metal being more transparent to the rays along these planes than is the surrounding metal.

In the examination of flakes to show their relation to the structural features of the steel, it is essential that the study be made upon samples showing very small flakes. Figs. 4 and 8 show that the flake is a discontinuity within the metal often of very appreciable width. Fig. 10a shows a section through one of the flakes in the gun forging shown in Fig. 4. The metal has been etched with copper-ammonium-chloride solution to show the non-metallic or slag inclusions. Although the steel is very

badly contaminated with such inclusions, little if any relation between these inclusions and the course of the flake can be traced. In Fig. 10b, however, which shows a very small flake in the same material, the inclusions that permitted the separation of the metal to occur and determined the course that the flake took are very evident.

Microstructure

When a section of flaky steel at right angles to the general plane of the flake is examined after properly polishing and etching, it is seen that the metal bordering the flake is normal in its structure up to the immediate face of the separation; that is, the flake has no depth. Figs. 11 and 12 show the structure of a chrome-nickel steel and a plain nickel steel, as

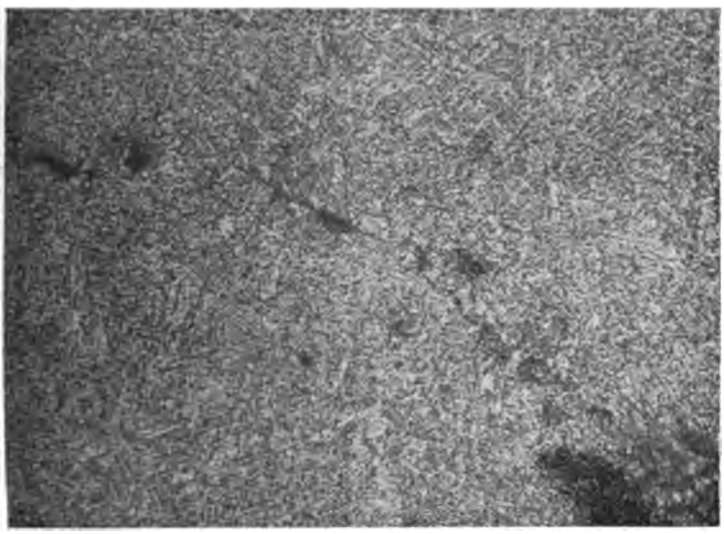


Fig. 11.—Chrome-nickel steel forging showing section through flake; structure is normal up to face of flake. Two per cent. alcoholic nitric acid. × 500.

related to a flake extending through the piece. The flake appears as a discontinuity in otherwise normal material. Fig. 13 shows a section of the same specimen after quenching; the metal is hardened uniformly throughout, the coarsely crystalline appearance noted on the face of the flakes in such material, Fig. 3, is a surface configuration only—the real grain of the metal constituting the flake is refined to the same degree as elsewhere in the specimen. The discontinuity in the metal, which in the fracture appears as the flake, is an intercrystalline one. Fig. 14, which shows the structure of a billet of chrome-nickel steel before receiving any heat treatment whatever, shows how closely the course of the

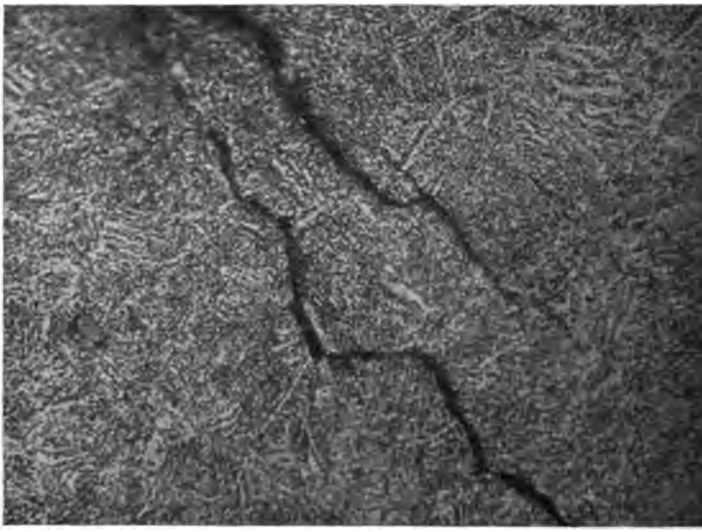


FIG. 12.—NICKEL-STEEL GUN FORGING, HEAT TREATED, SHOWING SECTION THROUGH A FLAKE, C, 0.37; NI, 2.83; CR, 0.01. MICROSTRUCTURE OF METAL IS NORMAL UP TO IMMEDIATE FACE OF FLAKE. ETCHING, 2 PER CENT. ALCOHOLIC NITRIC ACID. × 500.

FIG. 13.—MATERIAL SAME AS FIG. 12 AFTER HARDENING. ETCHING, 2 PER CENT. ALCOHOLIC NITRIC ACID. × 500.

flake follows the grain boundaries, which here are plainly shown by the different orientation of ferrite planes within the different crystals. The

FIG. 14.—SECTION OF CHROME-NICKEL BILLET AS ROLLED SHOWING INTERCRYSTALLINE FLAKES. ETCHING, 2 PER CENT. ALCOHOLIC NITRIC ACID. × 500.

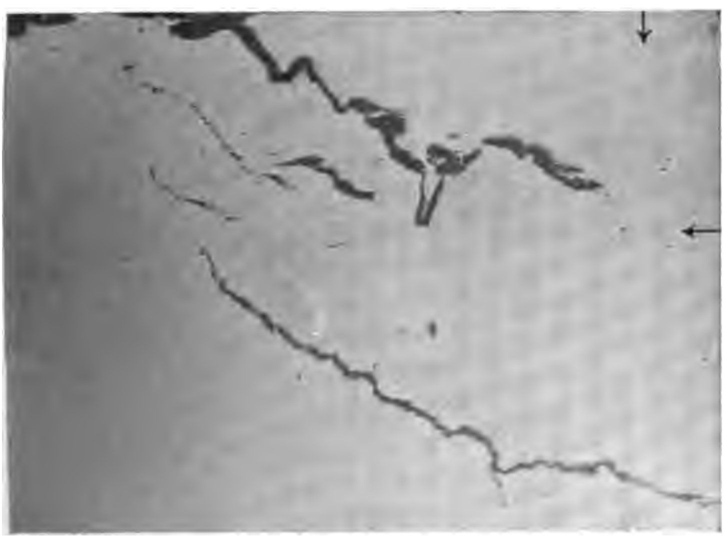


FIG. 15.—NICKEL-STEEL GUN FORGING, SAME MATERIAL AS FIG. 4, SHOWING APPEARANCE OF FLAKES IN MATERIAL AS POLISHED BUT UNETCHED. × 100.

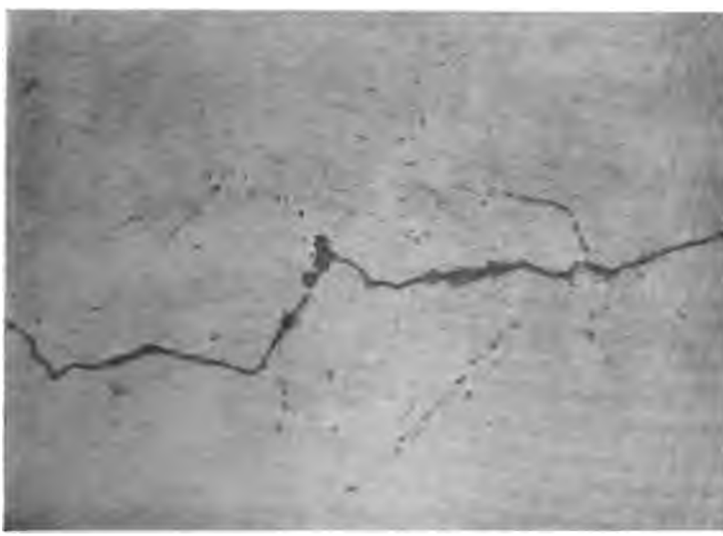
presence of flakes in this billet was first demonstrated by polishing a cross-section of the billet. A series of interior radial cracks was found which, when broken open, had the characteristic appearance of flakes.

Fig. 16.—Nickel-steel forging, extreme end of flake indicated by arrows in Fig. 15 is shown to consist of an extremely thin film of slag. Unetched. $\times$ 500.

The intercrystalline nature of the separation naturally leads to the examination of the material for the presence of intercrystalline inclusions or other features, which would account for the separation taking place in this manner. The examination must be restricted to very small flakes or to the extreme edges of those of larger size. Fig. 15 shows the appearance of a flake at a moderate magnification—the flake appears merely as a crevice or discontinuity in the metal. It is best to limit the examination at higher magnification to the fine hair-like cracks or extensions of flakes at the ends of the wider openings, as is indicated by the arrows. Fig. 16 shows such a crack, which in reality consists of an extremely thin film of slag (magnification 500 diameters). Figs. 17a and b show sections of the film in two other similar flakes, these films may also be readily seen, if present, by first annealing the metal; Figs. 18a and b illustrate this. The film is often discontinuous and shows breaks in it; in Fig. 19, it occurs as a continuation of isolated globules in chrome-nickel steel, carbon 0.39, nickel 3.08, chromium 0.87. Fig. 20 shows a flake the course of which is outlined by slag, the globules of which are much larger. In general an examination of the more open part of the flake shows little that is suggestive. Occasionally, however, isolated globules of glassy slag may be detected within the opening, as in Fig. 21. By deep grinding so that the outer margin of the flake is sectioned, particularly if the section is slightly oblique to the plane of the flake, traces of a glassy slag may be found in the cavities, as in Fig. 22. The wide portions of the crevice, on the whole, however, are not found to be completely filled with a continuous slag film.

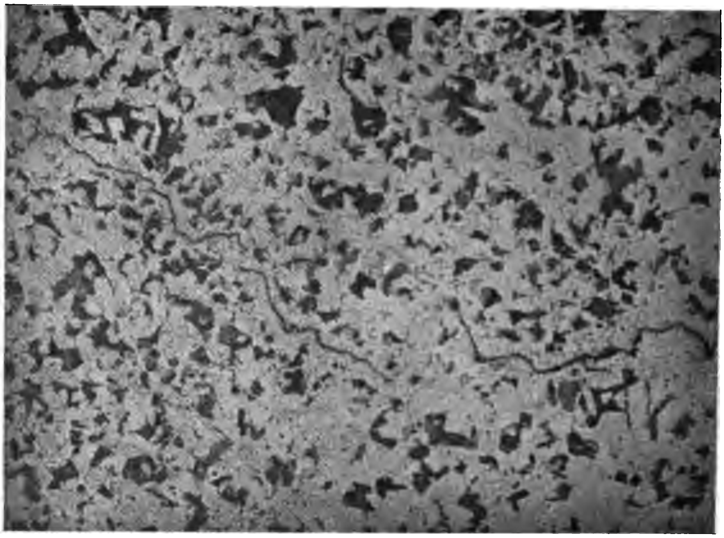
Upon etching the specimens showing slag films with hot alkaline sodium picrate, it is noted that, in general, the gray color of the

a

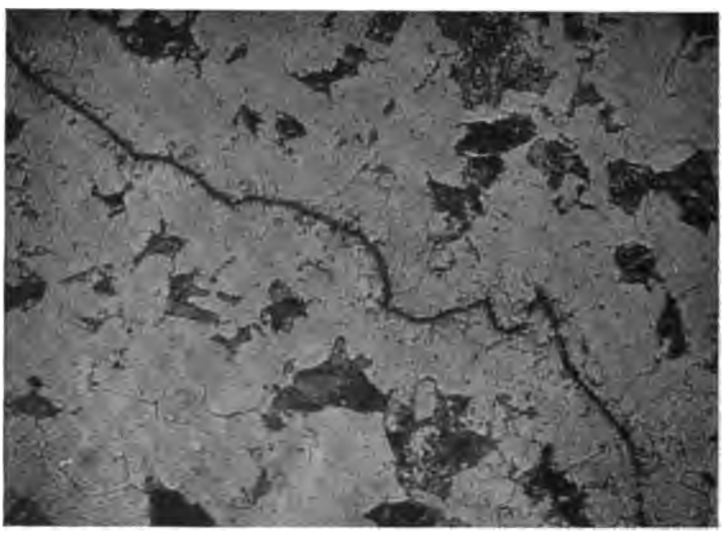


b

FIG. 17, *a* and *b*.—NICKEL-STEEL FORGING, SAME MATERIAL AS FIG. 12, SHOWING SLAG FILMS ENCLOSED WITHIN THE FLAKE. UNETCHED. × 500.



a



b

FIG. 18.—MATERIAL SHOWING SLAG FILMS ENCLOSED BY THE FLAKE SIMILAR TO FIG. 17, AFTER ANNEALING. ETCHING, 2 PER CENT. ALCOHOLIC NITRIC ACID. *a*, × 100; *b*, × 500.

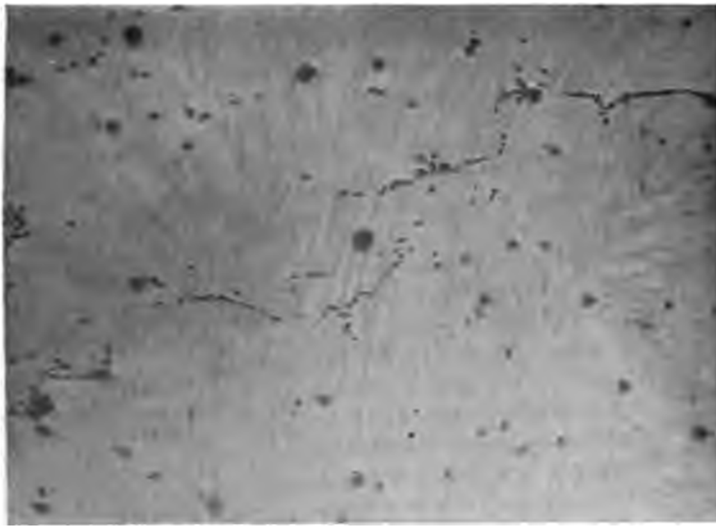


FIG. 19.—CHROME-NICKEL STEEL FORGING, MATERIAL SIMILAR TO FIG. 11, SHOWING TINY SLAG INCLUSIONS WITHIN THE FLAKE. UNETCHED. × 100.

FIG. 20.—CHROME-NICKEL STEEL FORGING, SAME AS MATERIAL IN FIG. 19, SHOWING FLAKE OUTLINED BY SLAG INCLUSIONS. UNETCHED. × 500.

FIG. 21.—NICKEL-STEEL FORGING, SAME MATERIAL AS FIG. 4, SHOWING SLAG GLOBULES ENCLOSED WITHIN WIDER PART OF CREVICE OF FLAKE. UNETCHED. × 500.

FIG. 22.—NICKEL-STEEL CONTAINING FLAKES, SAME MATERIAL AS FIG. 12, SHOWING TRACES OF SLAG ENCLOSED WITHIN CREVICES OF FLAKE. ETCHED WITH HOT ALKALINE SODIUM PICRATE. × 500.

film is not changed. The work of Comstock[1] has shown that this is an indication that such inclusions are of the nature of true slag rather than sulfide.

Probable Nature of Flakes

The results of every kind of examination of flaky steel indicate that flakes are discontinuities within the steel. These discontinuities are often found to be associated with extremely thin films of slag which are either continuous or formed of tiny isolated globules. The appearance of the face of the flake to the unaided eye or when examined with a hand magnifier suggests strongly that the defect had its origin early in the history of the metal. The coarse crystals have rounded corners and faces and in general the appearance suggests plastic bodies that have been

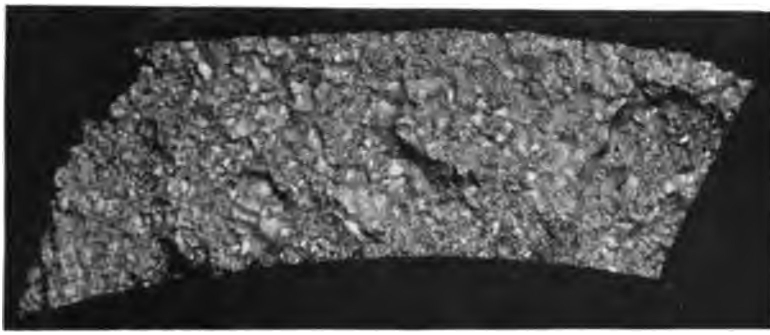


Fig. 23.—Fracture of defective chrome-nickel steel showing conditions within ingot. Sample was from 30-in. ingot about 5 in. from center; natural size.

squeezed together and failed to adhere. There is no trace of the glistening cleavage faces of crystals, which are always to be found when a coarsely grained metal breaks normally, that is by an intracrystalline break. The usual symmetrical arrangement of the flakes, except in forgings of which parts have been very much displaced, such as the twisted portions of crankshafts, also suggests that they were formed early in the history of the piece. The fact that the flakes are all intercrystalline in their nature also confirms this. The sectioning of large-sized blooms and of ingots has amply verified the conclusions based on observations of the finished forgings and demonstrated that the defect originates in the ingot and persists throughout the entire forging period and the subsequent heat treatment.

Although flakes have been found to be associated with slag inclusions, either as thin films or as isolated globular masses, the fact that steel is "dirty" is by no means a sure or safe criterion for condemning it as

[1] G. F. Comstock: *Trans.* (1916) **56**, 553–560.

"flaky." Without doubt, however, the presence of slag inclusions, which later may be squeezed down to the form of films, is a condition that aids very materially in permitting a separation of the metal to occur and also assists in the prevention of the subsequent welding up of such interior cavities. While inclusions and slag films have been found associated with flakes in a large number of specimens of flaky steel examined, in a considerable number of samples such conditions were not found.

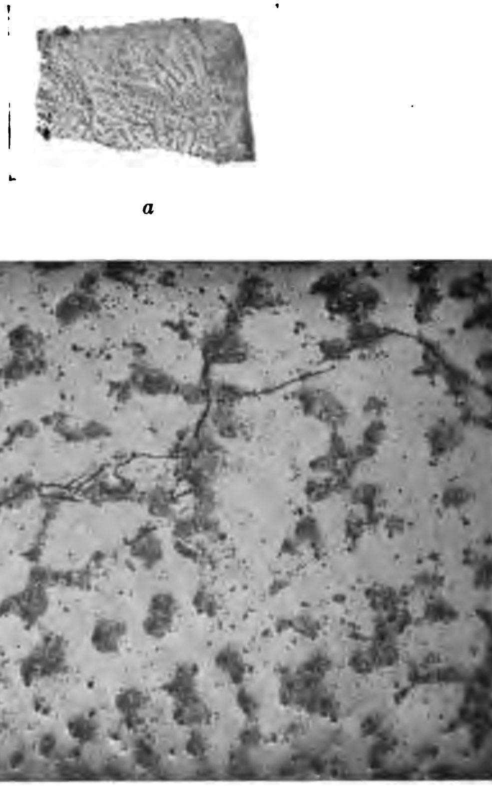


FIG. 24.—*a*, SECTION OF MATERIAL OF FIG. 23, ETCHED WITH 2 PER CENT. COPPER-AMMONIUM CHLORIDE SOLUTION TO SHOW THE DENDRITIC STRUCTURE AND SHRINKAGE CRACKS; NATURAL SIZE. *b*. SAME MATERIAL, × 15. INTERIOR CRACKS, WHICH GIVE RISE TO FRACTURE SHOWN IN FIG. 23, OCCUR IN BETWEEN THE DENDRITES WHERE THE SLAG INCLUSIONS ARE LOCALIZED.

Particularly was this true of many of the nickel-chromium steels examined. Hence no general statement can be made that the presence of such inclusions is a necessary condition for the formation of flakes. This condition, however, if it existed would aid very materially in their formation.

In Fig. 23 is shown the appearance of a specimen taken from the interior of an ingot of defective chrome-nickel steel of the composition,

carbon 0.40, chromium 0.35, nickel 2.75. The condition revealed in the fracture without doubt represents the initial or ingot condition of the defect, which later in the history of this piece would be designated as flakes. The dull smooth coarsely crystalline spots in the fractures have the appearance of metal that has failed to unite to the adjacent metal. A section through the specimen is shown in Fig. 24; the coarse dendritic structure characteristic of the cast metal is clearly shown, also some interior crevices continuous with the smooth surface areas of the fracture. These cracks occur between the fingers of the dendrites, which is the portion of the metal that is the last to solidify and contains most of the inclusions (Fig. 24b) and hence is the weakest part of the steel. The

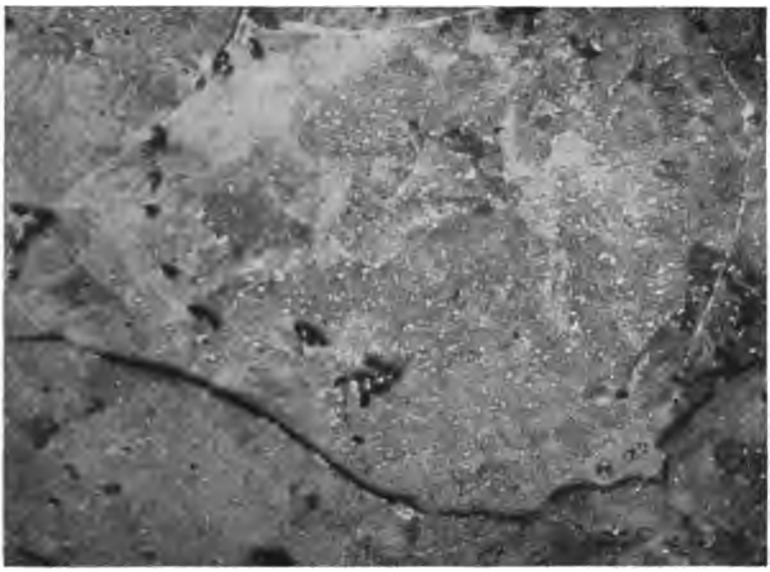


FIG. 25.—SAME MATERIAL AS FIG. 23; INGOT-CRACKS ARE LARGELY INTERCRYSTALLINE. ETCHING, 2 PER CENT. ALCOHOLIC NITRIC ACID. × 50.

cracks have the same appearance as the shrinkage cracks often found in defective castings of bronze and brass. Such shrinkage cracks invariably form in the crevices between the branches of the dendrites and so far as can be judged from their microscopic appearance these ingot cracks in steel should be considered as of similar origin. Fig. 26 shows how these shrinkage cracks often pass through slag globules of considerable size; such globules, upon forging the metal into shape, may result in the thin films shown in Figs. 16 and 17. Fig. 25 illustrates the intercrystalline nature of these ingot cracks.

Another type of defect in steel, very closely related to flakes, is the so-called "silver streaks;" Fig. 27 illustrates the appearance of these in a chrome-nickel steel. Each white elongated patch shows in its center a

tiny thread of greenish slag and the surrounding metal has the appearance, as in a true flake, of never having been in direct union with the opposing metal. Other spots, larger than the silver streaks shown, containing rather prominent slag plates have often been noted in the faces of fractures of steel. The metal underlying and surrounding such slag plates has the bright clean silvery appearance found in the flakes. Such spots are usually designated as crystalline breaks due to the presence of slag. It appears very probable that such defects are due entirely to rolled out slag plates and that the presence of initial shrinkage crevices or ingot cracks is not necessary for their formation. Defects of this type are usually revealed in steel that is tested transversely; that is, the

FIG. 26.—SAME MATERIAL AS FIG. 23. SLAG GLOBULE LYING IN COURSE OF CRACK, UPON FORGING STEEL, WOULD PROBABLY RESULT IN FILM-LIKE ENCLOSURES SIMILAR TO THOSE OF FIGS. 16 AND 17. UNETCHED. × 100.

specimen is taken so that its axis is perpendicular to the fibers, due to forging, instead of parallel as is the usual case. Flakes, however, are found in both transverse and longitudinal sections; in chrome-nickel steel, in particular, they are found to extend in all directions in the ingot. In the plain nickel steels they are usually more symmetrically arranged.

On the whole, the microscopic appearance of flaky steel leads to the following conclusions regarding the nature and origin of flakes. They originate in the ingot, in which state they have the appearance of intercrystalline shrinkage cracks. They occur in the cast metal along with the slag inclusions in the angles between the branches of the tree-like dendritic crystals. They persist throughout the history of the forging into the finished form as discontinuities in the metal, often associated with slag films, which have resulted from the working down of the slag inclusions

with which they are associated from the beginning. The coarsely crystalline appearance of the flake is a surface configuration only and is a record of the crystalline condition, that is, the dendrites, existing in the steel at

FIG. 27.—FRACTURE OF CHROME-NICKEL STEEL FORGING SHOWING DEFECT OF SILVER STREAKS; EACH WHITE ELLIPTIC AREA CONTAINS A SHORT THREAD OF GLASSY SLAG. NATURAL SIZE.

the time the discontinuity originated. Though they are usually associated with dirty steel, the converse is not true; the fact that steel is dirty or badly contaminated with slag inclusions is not a sure criterion for condemning the metal as defective because of flakes.

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Flaky and Woody Fractures in Nickel-steel Gun Forgings

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(New York Meeting, February, 1919)

In connection with certain coöperative work carried on between the Ordnance Department of the U. S. Army, the U. S. Bureau of Mines, and the U. S. Geological Survey during the year 1918, it was the writers' privilege to make metallographic examinations of a great many test bars and other pieces of nickel-steel gun forgings. The material studied came from many different steel plants throughout the country and consisted both of forgings that had been accepted by the Ordnance Department and those that had failed to pass the specified physical tests. In general, these tests require a minimum tensile strength of 95,000 lb. (42,091 kg.), an elastic limit of 65,000 lb. (29,483 kg.), an 18 per cent. elongation, and a 30 per cent. reduction in area. An average chemical composition of the steel studied is 0.38 per cent. carbon and 2.9 per cent. nickel. The steel was of both basic electric and basic open-hearth manufacture. The object of the metallographic work was two-fold: to assist in detecting defects in the steel and, if possible, to suggest remedies for the same; and to obtain as much information as possible in regard to the relation of the microstructure of the metal to its physical properties. The greater part of the investigation was devoted to defective metal that failed to pass the ordnance specifications. Many types and kinds of more or less serious defects thus came under observation, but most of these were due to the attempts by the manufacturer to meet the enormous demand for ordnance steel with more or less inadequate equipment, and were soon remedied.

Two defects, the so-called "flakes" or "snowflakes" and a certain "fibrous" or "woody" fracture, were encountered so frequently and were so disastrous to the steel that the greater part of the study was devoted to them. As a result much information as to their nature and their effects

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upon the steel and something in regard to some of the conditions that favor their development has been obtained. The purpose of the present paper is to present a brief description of these defects, with the thought that this information will produce a discussion that may result in the solution of a very troublesome and, in some instances, a very serious problem in the manufacture of large nickel-steel forgings. The writers request the fullest and most unreserved criticism of any part of the paper.

Location of Defects

Both woody, or fibrous, texture and flakes appear most prominently in the steel when it is broken in a direction transverse to that of elongation in forging. Either defect when present is shown to good advantage in any transverse fracture of the metal, whether pulled test bars or nicked and broken, or split, blocks.

Woody Fracture

Woody fracture is a term used by ordnance inspectors to describe the fracture of a pulled test bar that has a fibrous appearance and to a certain extent resembles the fracture of a piece of wood, such a fracture is shown in Figs. 13 and 15. In some instances, this type of fracture has a decided "platy" appearance and occasionally careful examination will reveal more or less foreign matter, largely slag, between the plates or fibers in the fracture. The foreign matter is by no means present in all, nor even in the majority of such fractures. In fact, it was only in the beginning of the greatly increased demand for ordnance steel due to the war, when the manufacturers were making such great efforts to supply ordnance material with more or less inadequate equipment, that slag and other foreign matter were present in sufficient amount to cause trouble. This was soon remedied. The woody fractures in many cases still remained even in steel that leaves little to be desired as to freedom from sulfide, slag, and similar impurities, showing clearly that such fractures are due to a condition of the steel itself and not to foreign inclusions.

Two features that appear to be characteristic of both the woody and the flaky steel are brought out when polished surfaces of the metal are etched for either macroscopic or microscopic study. Copper-bearing etch mediums, such as Rosenhain and Haughton's, Stead's, or Stead-Le Chatelier's reagents, never fail to reveal a decidedly non-homogeneous metal with large and prominent but much elongated dendrites. These features are illustrated in Figs. 27, 28, and 29. The microstructure, as brought out by any of the commonly used etch reagents, such as picric acid or amylic nitrate, closely resembles that of flaky steel and will be described in the paragraph devoted to that subject.

FIG. 1.—FULL CUP DULL GRAY FRACTURE OF BAR 16. × 3½.

FIG. 2.—MICROSTRUCTURE OF BAR 16 ETCHED WITH PICRIC ACID. COMPLETELY GRAIN-REFINED AND SORBITIZED. × 260.

FIG. 3.—THREE-QUARTER LIPPED STAR FRACTURE, DENSE, FINE GRAY OF BAR 7. × 3½.

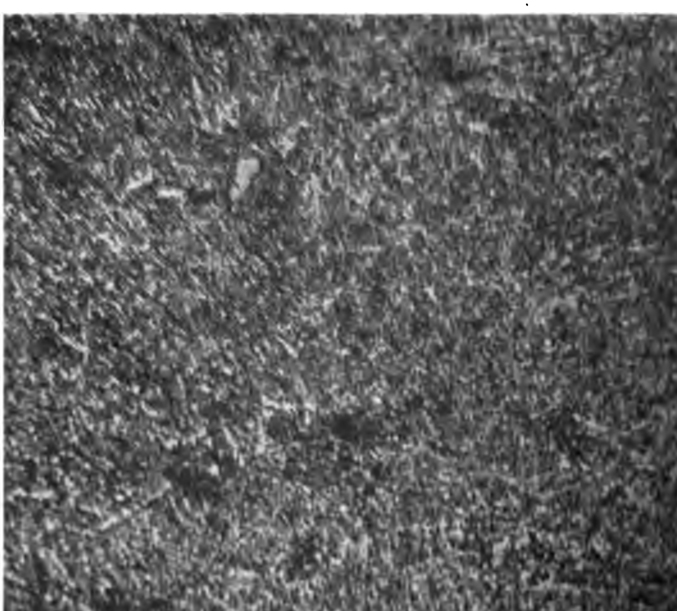

FIG. 4.—MICROSTRUCTURE OF BAR 7 ETCHED WITH PICRIC ACID. SEEMINGLY GRAIN-REFINED BUT SHOWING SOME FREE FERRITE. × 260.

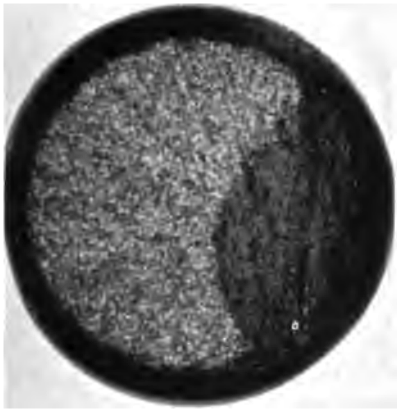

FIG. 5.—FRACTURE OF BAR 20. ANGULAR. 75 PER CENT. FINE CRYSTALLINE AND 25 PER CENT. LAMINATED WITH STREAKS. × 3½.

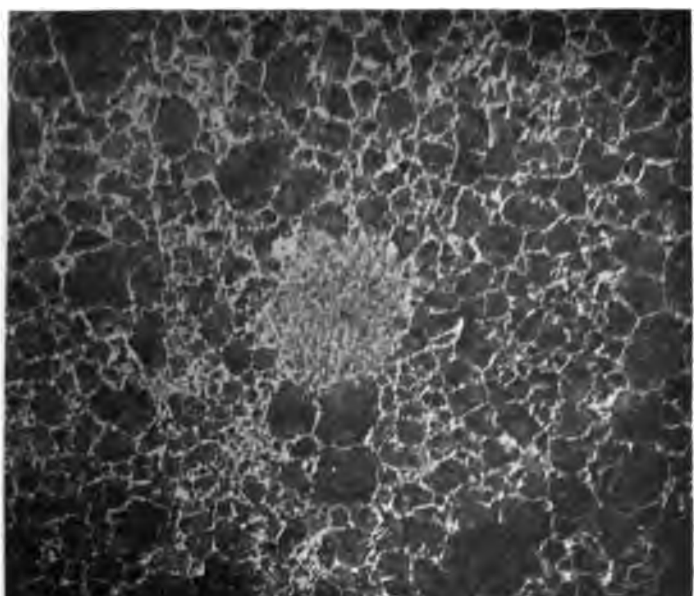

FIG. 6.—MICROSTRUCTURE OF BAR 20 ETCHED WITH PICRIC ACID. AN UNEVEN NETWORK WITH EXCESSIVE FERRITE PRECIPITATION IN SEGREGATED AREAS. HIGHER MAGNIFICATION SHOWS FERRITE AREAS TO CONTAIN NUMEROUS INCLUSIONS. × 260.

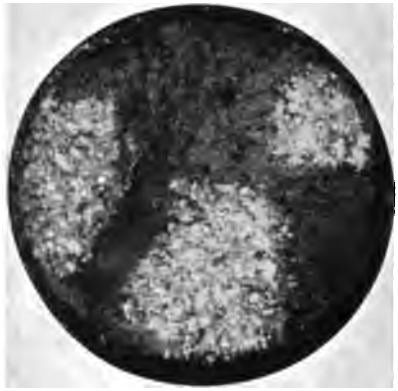

FIG. 7.—FRACTURE OF BAR 36. SILKY AND LAMINATED WITH ABOUT 50 PER CENT. FLAKE. × 3½.

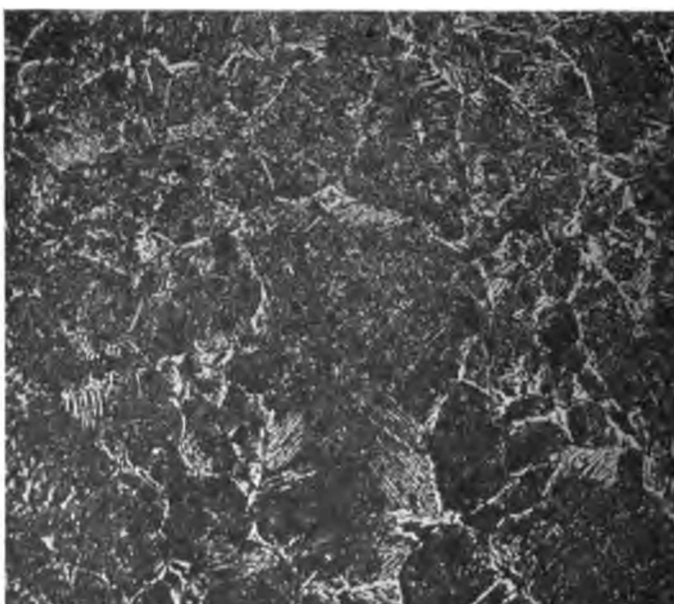

FIG. 8.—MICROSTRUCTURE OF BAR 36 ETCHED WITH PICRIC ACID. COARSE NETWORK OF NEEDLE-LIKE FERRITE AND SORBITE. AREAS CONTAINING CARBON SHOWN TO BE IN SOME INSTANCES SORBITIC AND IN OTHERS APPROACHING TRUE PEARLITIC. × 260.

FIG. 9.—FRACTURE OF BAR 38. ABOUT 75 PER CENT. FINE GRANULAR AND 25 PER CENT. LAMINATED WITH FLAKE. × 3½.

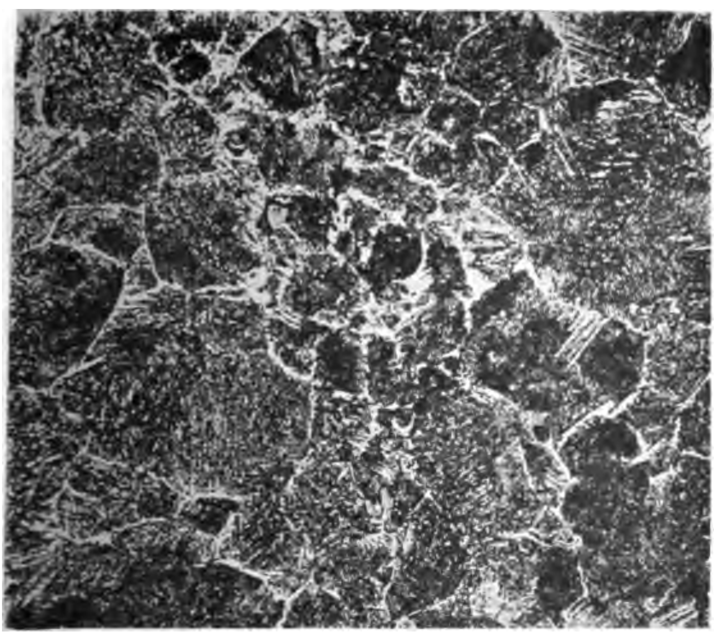

FIG. 10.—MICROSTRUCTURE OF BAR 38 ETCHED WITH PICRIC ACID. COARSE NETWORK OF NEEDLE-LIKE FERRITE AND SORBITE, LATTER IN CERTAIN AREAS CONVERTED TO LAMINATED PEARLITE. MORE FREE FERRITE SHOWN THAN IN FIG. 8. × 260.

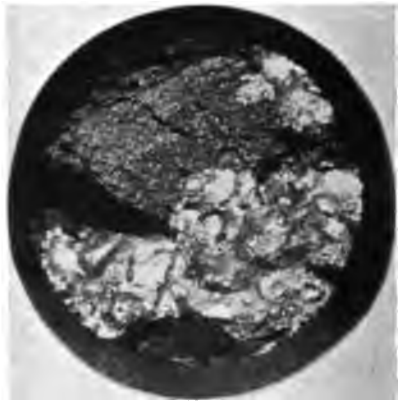

FIG. 11.—FRACTURE OF BAR 032. ABOUT 50 PER CENT. FINE GRANULAR AND 50 PER CENT. COARSE FLAKE. × 3½.

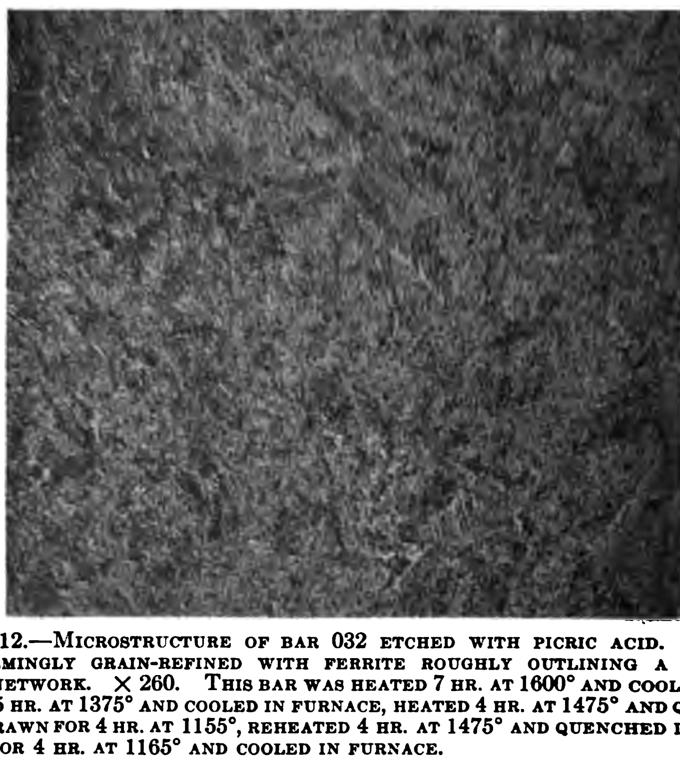

FIG. 12.—MICROSTRUCTURE OF BAR 032 ETCHED WITH PICRIC ACID. SORBITIC AND SEEMINGLY GRAIN-REFINED WITH FERRITE ROUGHLY OUTLINING A PREVIOUS COARSE NETWORK. × 260. THIS BAR WAS HEATED 7 HR. AT 1600° AND COOLED IN AIR, HEATED 5 HR. AT 1375° AND COOLED IN FURNACE, HEATED 4 HR. AT 1475° AND QUENCHED IN OIL, DRAWN FOR 4 HR. AT 1155°, REHEATED 4 HR. AT 1475° AND QUENCHED IN WATER, DRAWN FOR 4 HR. AT 1165° AND COOLED IN FURNACE.

FIG. 13.—FRACTURE OF BAR 39. LAMINATED OR WOODY WITH SLAG. × 3½.

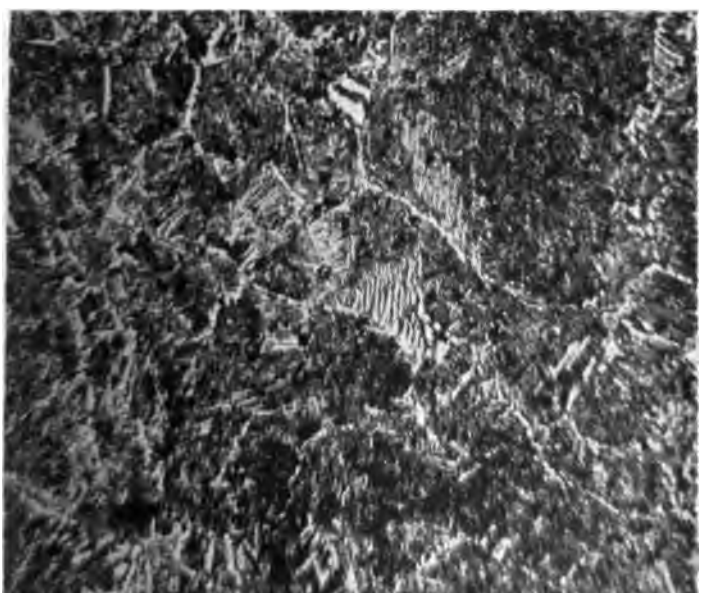

FIG. 14.—MICROSTRUCTURE OF BAR 39 ETCHED WITH PICRIC ACID. COARSE NETWORK OF NEEDLE-LIKE FERRITE AND SORBITE WITH WIDER AREAS OF FERRITE. × 260.

FIG. 15.—FRACTURE OF BAR 8 LAMINATED OR WOODY WITH STREAKS AND SLAG. × 3½.

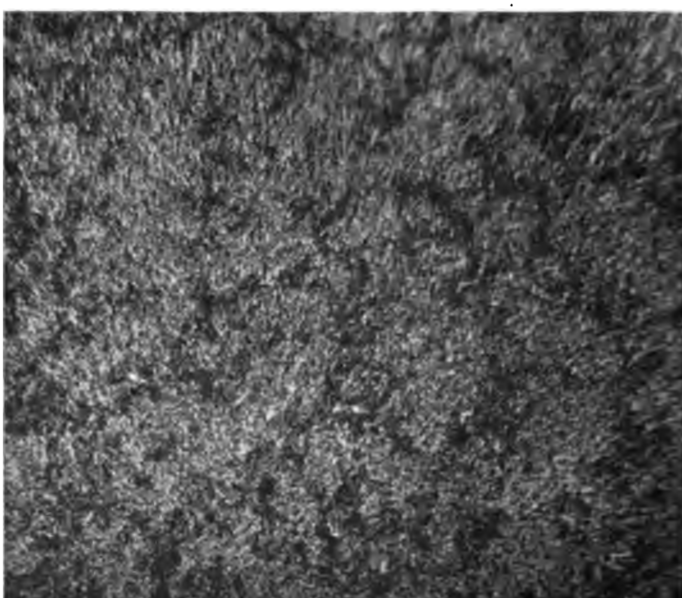

FIG. 16.—MICROSTRUCTURE OF BAR 8 ETCHED WITH PICRIC ACID. SEEMINGLY GRAIN-REFINED SORBITE, BUT CLOSE EXAMINATION SHOWS DARK FUZZY LINES INCLOSING THIN FERRITE STREAKS AND ROUGHLY OUTLINING A PREVIOUS NETWORK. × 260.

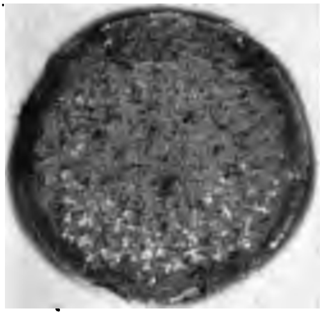

FIG. 17.—FRACTURE OF BAR 18 ONE-HALF LIP. 40 PER CENT. FINE CRYSTALLINE FINE GRANULAR AND 60 PER CENT. GRAY LAMINATED.

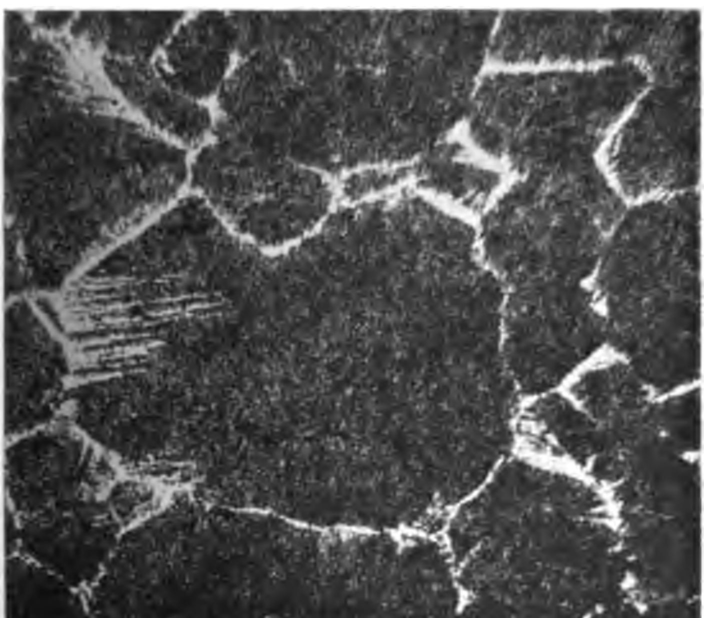

FIG. 18.—MICROSTRUCTURE OF BAR 18 ETCHED WITH PICRIC ACID. EXCEEDINGLY COARSE NETWORK OF SORBITE AND NEEDLE-LIKE FERRITE. COARSEST NETWORK EXHIBITED BY ANY SPECIMEN OF HEAT-TREATED NICKEL-STEEL FORGINGS EXAMINED IN THIS LABORATORY. × 260.

FIG. 19.—PHOTOGRAPH OF TEST PIECE SHOWING CRACKS THAT DEVELOP IN FLAKY BARS AT RIGHT ANGLES TO THE DIRECTION OF PULL. × 3½.

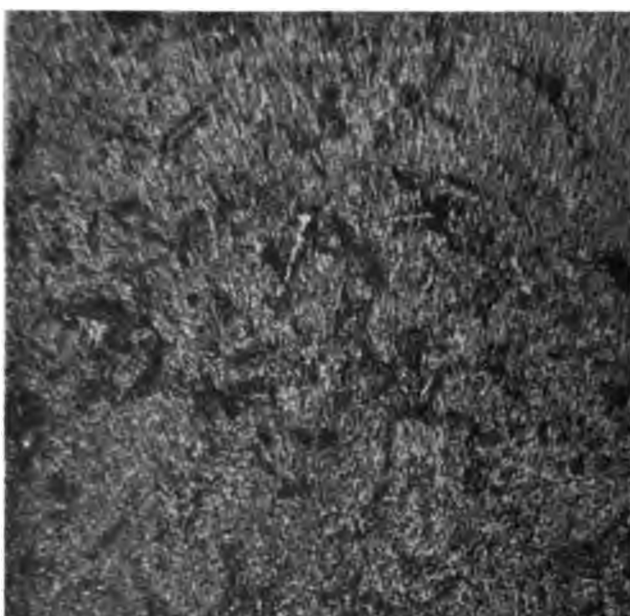

FIG. 20.—MICROSTRUCTURE OF BAR. SEEMINGLY GRAIN-REFINED, BUT PREVIOUS COARSE NETWORK IS ROUGHLY OUTLINED BY FERRITE AND A CONSTITUENT WHICH ETCHES DARKER THAN SORBITE. COMPARE WITH FIGS. 12 AND 16.

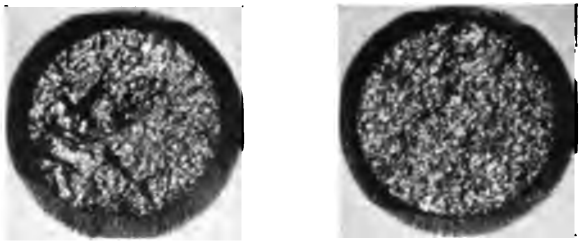

FIG. 21.—TEST-BAR FRACTURES, MUZZLE AND BREECH OF FORGING 1348 UNTREATED. SEE FIGS. 36 TO 41. × 2.

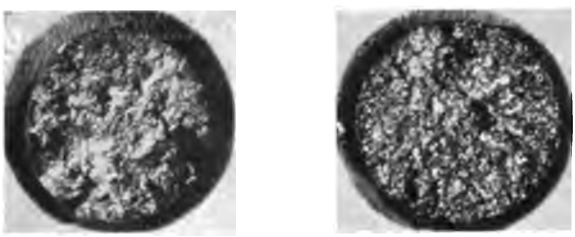

FIG. 22.—TEST-BAR FRACTURES, MUZZLE AND BREECH OF FORGING 1351 UNTREATED. SEE FIGS. 30 TO 35. × 2.

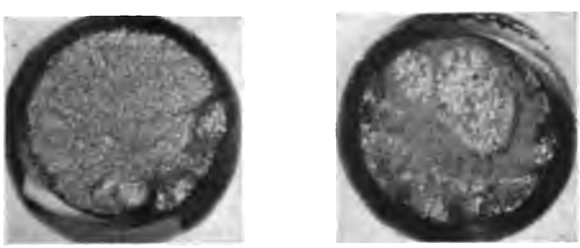

FIG. 23.—TEST-BAR FRACTURES FROM TREATED FORGING 948C. × 2.

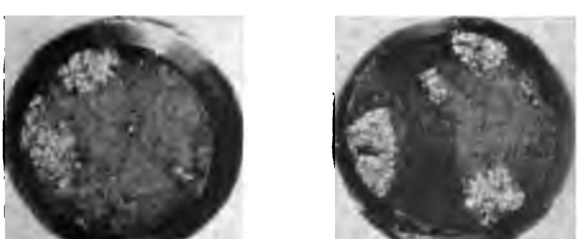

FIG. 24.—FRACTURES TEST-BAR 948D. SAME FORGING AS FIG. 23 AFTER ADDITIONAL QUENCH AND DRAW. × 2.

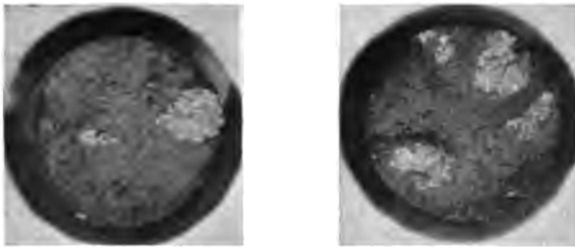

FIG. 25.—FRACTURES TEST-BAR 948B. SAME FORGING AS FIG. 23 AFTER TWO QUENCHES AND A DRAW. × 2.

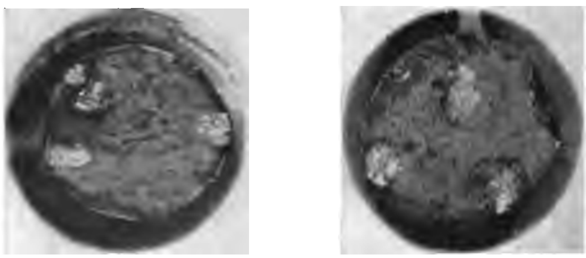

FIG. 26.—FRACTURES TEST-BAR 948A. SAME FORGING AS FIG. 23 AFTER AN ANNEAL, TWO QUENCHES AND A DRAW. × 2.

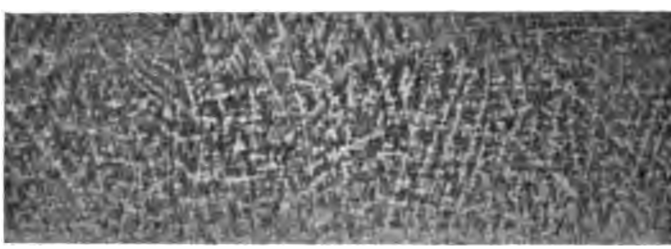

FIG. 27.—DENDRITIC STRUCTURE. SPEC. 948C FROM FORGING THAT HAD BEEN ANNEALED, QUENCHED AND DRAWN. ETCHED WITH STEAD REAGENT. × 2⅘.

FIG. 28.—DENDRITIC STRUCTURE. SPEC. 948A FROM SAME FORGING AS FIG. 23, AFTER AN ANNEAL, TWO QUENCHES AND A DRAW. ETCHED WITH STEAD REAGENT. × 2⅘.

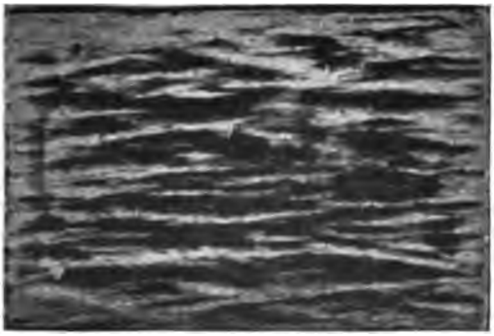

FIG. 29.—DENDRITIC STRUCTURE. EFFECT OF HOT-WORKING ON DENDRITES. SPECIMEN FROM ACCEPTED HEAT-TREATED GUN FORGING. ETCHED WITH STEAD REAGENT. × 2⅘.

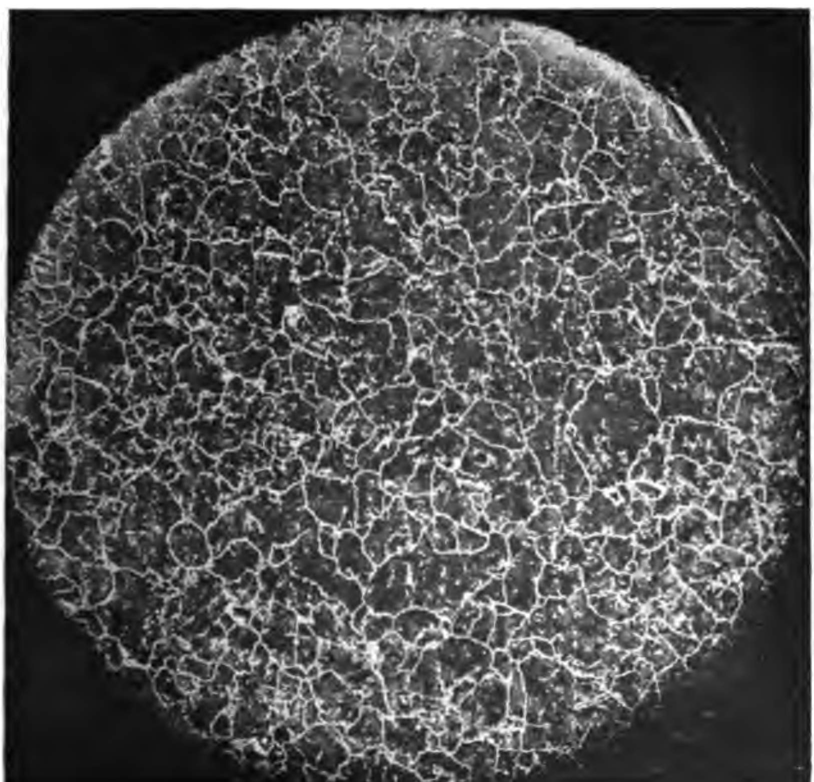

FIG. 30.—CROSS-SECTION OF SCREW END OF TEST BAR FROM FORGING 1351, TAKEN OUT OF BREECH AND OF FORGING, UNTREATED. PICRIC ACID ETCH. × 6. PHYSICAL PROPERTIES: T.S. 90500; EL. 55000; EXT. 5.0 PER CENT.; CONT. 3.9 PER CENT.

Flakes and Flaky Fracture

It is believed that the terms flake and snowflake were first used by ordnance inspectors to designate the peculiar bright crystalline to granular silvery spots found in the fractured ends of pulled test bars from cannon forgings containing the type of defect now under consideration. The term flake has been rather loosely used and has been applied to any bright spots or areas in the fracture of broken test pieces. While possibly not the most desirable name for the defect, it is at least some-

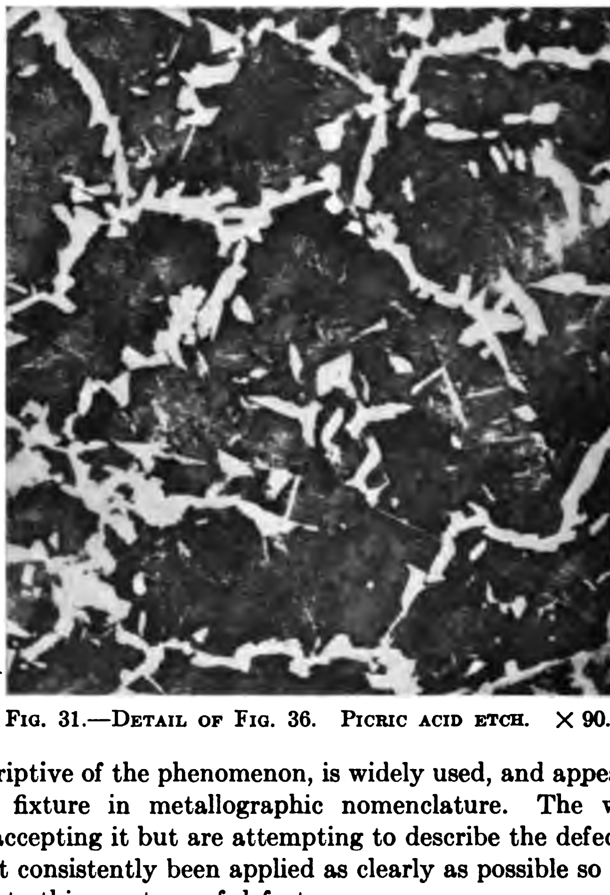

Fig. 31.—Detail of Fig. 36. Picric acid etch. × 90.

what descriptive of the phenomenon, is widely used, and appears to have become a fixture in metallographic nomenclature. The writers are therefore accepting it but are attempting to describe the defect to which it has most consistently been applied as clearly as possible so that it will be limited to this one type of defect.

To the unaided eye, a flaky fracture is any type of fracture in which occur bright, silvery spots or areas. These spots vary usually from $\frac{1}{16}$ to $\frac{1}{2}$ in. (1.5 to 12.7 mm.) in longest diameter and are surrounded by the usual gray to smoke-colored metal, which may be woody, silky, or granular, the silvery spots being the flakes, or snowflakes. A closer examination with a hand lens, or better with a binocular microscope,

reliable qualitative and microchemical work has been done, all of which indicates that the flake areas are higher in phosphorus and carbon than the normal metal. In etching flaky steel for macroscopic examination, it was noted, as is illustrated in Figs. 46 and 47, that the flake areas were attacked more readily than the normal steel and if the sample were permitted to remain long in the acid the flake area was eaten out and resembled a minute crack. Also, when a carefully polished surface of flaky steel was etched with any of the copper-bearing etch mediums, the results invariably indicated that the flake areas differed in composition or condition from the rest of the metal.

Effect of Flakes

The physical properties determined upon the bars coming to the writers' attention are elastic limit, tensile strength, elongation, and reduction in area. In applying the load on a tensile machine, an interesting phenomenon was observed. As shown in Fig. 19, throughout the bar small cracks developed at right angles to the direction of stress; these cracks are without doubt flake areas. It is perhaps this phenomenon that has led some investigators to conclude that flakes are incipient cracks.

The most characteristic effects of flakes, as found in these bars, is the loss of ductility and corresponding decrease in reduction of area; the tensile strength and elastic limit are reduced but not so marked as these other properties. This is best shown by reference to bars 36, 38, and 032, which gave an elongation of 3.6, 6.8, and 0.0 per cent. and a reduction in area of 2.0, 4.5 and 0.0 per cent. (see Table 1). The corresponding tensile strengths are 62,900, 108,100 and 47,000 lb. (28,531, 49,033 and 21,318 kg.), respectively. The decrease in physical properties may or may not be dependent on the size of flakes. Generally speaking, the

TABLE 1.—*Chemical and Physical Properties of Test Bars*

No.	Type of Fracture	Chemical Analyses: C, Per Cent.	Mn, Per Cent.	Si, Per Cent.	S, Per Cent.	P, Per Cent.	Ni, Per Cent.	Physical Properties: Elastic Limit, Pounds Per Sq. In.	Tensile Strength, Pounds Per Sq. In.	Elongation, Per Cent.	Reduction in Area, Per Cent.
16	Cup	0.39	0.66	0.25	0.025	0.020	2.90	73,900	97,200	29.5	64.7
7	Star	0.41	0.79	0.29	0.011	0.020	2.87	78,700	108,600	24.5	63.5
8	Woody	0.42	0.60	0.122	0.019	0.019	3.14	72,800	87,000	5.5	17.7
18	Woody	0.41	0.66	0.25	0.015	0.020	2.98	66,700	115,900	19.5	39.5
20	Woody	0.10	0.55	0.15	0.021	0.025	2.85	62,900	97,300	7.0	7.8
36	Flake	0.44	0.66	0.34	0.021	0.020	3.29	61,900	62,900	2.0	3.6
38	Flake	0.37	0.59	0.19	0.019	0.020	3.09	73,400	108,100	4.5	6.8
032	Flake	0.38	0.69	0.24	0.033	0.043	3.24	47,000	47,000	0.0	0.0
39	Slag	0.41	0.36	0.23	0.040	0.036	3.27	77,000	106,600	9.0	11.8

smaller the flakes the better the steel but this is not always true, nor can it be said that these properties and the size of flakes are always definitely related. This is best shown by comparing bars 032 and 36 (Figs. 11 and 7). These bars show practically the same area of flake in the fracture, about 50 per cent., yet bar 032 shows a tensile strength of only 47,000 lb. while bar 36 shows a strength of 62,900 lb. The nature of the surface of the flake, that is, whether fine or coarse grained, may affect the physical properties and may explain the difference in properties in bar 032, which is very coarse grained, and bar 36, which is finer grained.

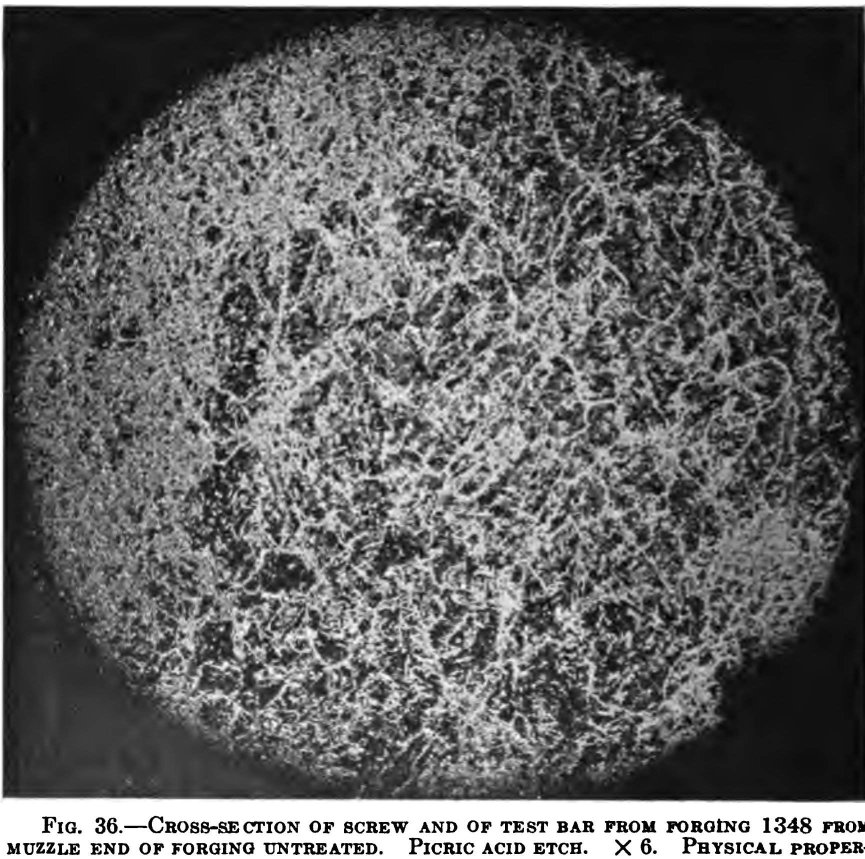

FIG. 36.—CROSS-SECTION OF SCREW AND OF TEST BAR FROM FORGING 1348 FROM MUZZLE END OF FORGING UNTREATED. PICRIC ACID ETCH. × 6. PHYSICAL PROPERTIES: T.S. 92000; E.L. 55000; EXT. 11 PER CENT.; CONT. 13.3 PER CENT.

SUGGESTED CAUSES OF FLAKES

The following suggestions have come to the attention of the writers as possible causes of flakes:

1. Foreign inclusions. Microexamination of a number of defective bars has failed to tie up in a conclusive manner foreign inclusions with

flaking. In fact, many such bars have been found that show the steel to be exceptionally clean in this respect.

2. Gaseous inclusions and cavities. Little investigation has been done along this line, but here again there has been little microscopic evidence that would warrant extensive research in this direction.

3. Scale and consequent local decarburization. It has been suggested that in rapid pouring the oxide film that forms on top of the metal may be churned in and entrapped in the metal on freezing. One would expect

FIG. 37.—DETAIL OF FIG. 42. PICRIC ACID ETCH. × 90.

in this event to find oxide inclusions but the writers have not found this to be so in even a majority of cases, and while in some instances oxides have been found they have not appeared in sufficient quantity to set this down as a primary cause of flaking.

4. Segregation of non-ferrous elements. The writers' experience in this matter is covered in the part of this paper dealing with the chemical composition of flakes.

5. Overheating and non-uniformity of heat of ingot preparatory to forging. This seems to the writers to be on fairly firm ground and is discussed at greater length elsewhere in this paper.

6. Shape of ingot and method of forging. In many cases square ingots forged on a flat die have been used. A change to octagon-shaped molds and forging in a V-shaped die decreased rejections to some extent; but as far as the writers' information goes, this change has not resulted in completely doing away with flaking.

7. Differential expansion of areas in heterogeneous metal. The suggestion is made that, where there are areas with varying coefficients of expansion, due to the more rapid expansion and contraction of certain

FIG. 38.—DETAIL OF FIG. 42. PICRIC ACID ETCH. × 90.

parts in heating and cooling, lines of weakness or even ruptures may be set up in the mass which upon being stressed break readily with low ductility.

CAUSE OF WOODY FRACTURE

Practically all suggestions as to the cause of woody fracture emanate from the same line of thought, that they are caused by the condition of the steel with respect to the original dendritic structure (Fig. 27) of the ingot; this appears quite a plausible theory. The theory has been advanced that slow cooling through the solidification zone will lead to large dendrites that, upon being drawn out at the forge, form long plates.

Rapid cooling through the solidification zone has been suggested as a remedy but the rapidity of the cooling must be governed by the chances of setting up bad secondary shrinkage in the ingot.

It is probable that laminated or woody fiber is produced, in a great measure, by the working of the original dendrites (Fig. 29) in parallel longitudinal lines by forging. The greater the amount of work applied,

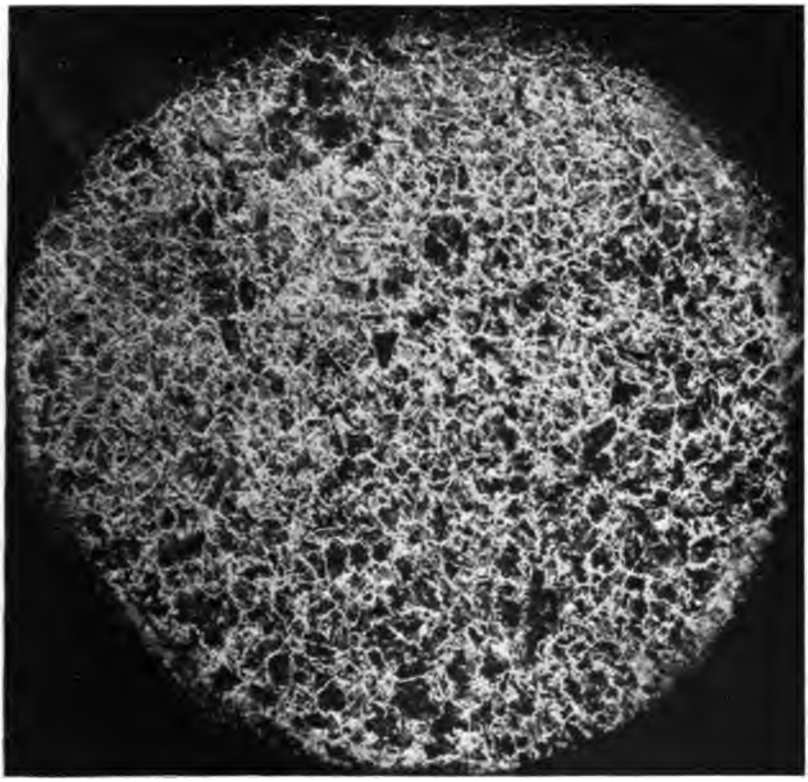

FIG. 39.—CROSS-SECTION OF SCREW END OF TEST BAR FROM FORGING 1348 FROM BREECH END OF FORGING UNTREATED. PICRIC ACID ETCH. × 6. PHYSICAL PROPERTIES: T.S. 90000; E.L. 50000; EXT. 8 PER CENT.; CONT. 9.6 PER CENT.

the longer and thinner these lines become; here may be found the cause of the exceptionally low transverse ductility in bars that show a decidedly laminated or woody structure in which fibers can be seen very plainly in the macrostructure (Fig. 29). Charpy[1] has shown the bad effect of hot working on the transverse ductility of steel and Portevin and Bernard[2]

[1] G. Charpy: Influence of Hot Deformation on the Qualities of Steel. *Engng.* [London] (Sept. 20, 1918) **106**, 310.

[2] A Portevin et V. Bernard: La Macrostructure de L'Acier. *Rev. de Mét.* (1918) **15**, 273-280.

were able to efface the remains of original dendritic structure only by annealing for 6 days at 850° C. (1562° F.) to 900° C. (1652° F.).

The persistence of dendritic structure after fairly severe treatment may be seen in Fig. 28. In this connection it may be said that anything which leads toward the production of a coarse fiber is undesirable. A basic steel, generally speaking, will fiber more readily than an acid steel and for this reason basic steel is desirable for armor where a fibrous back is essential. In the manufacture of nickel-steel gun forgings, where a coarse fiber is not desirable, acid steel has been most successfully used.

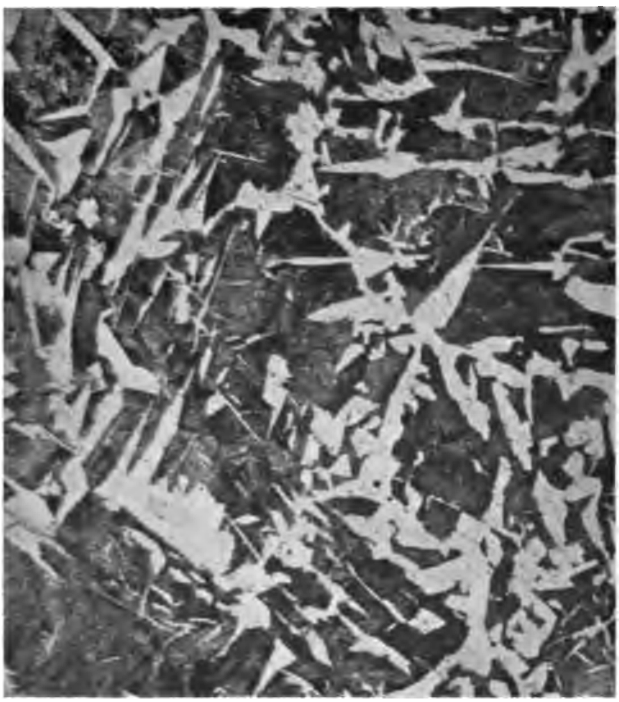

FIG. 40.—DETAIL OF FIG. 45. PICRIC ACID ETCH. × 90.

Hot working will deform dendrites and tend to form them into parallel bands, therefore, where transverse strains are to be withstood, hot working should be carried on only to the point that experience will dictate. This would suggest the use of longer ingots of smaller cross-section. But with ordinary plant practice it does not appear certain that such a change would not be jumping from the frying pan into the fire. Forging seems to be carried out, in a great many instances, at excessive temperature, resulting in finishing at too high a heat, so that with less work, due to the reduced size of the ingot, the dangers arising from high finishing

temperatures would be even greater and result in worse condition than could be brought about by an excessive deformation of dendrites.

Figs. 30 to 32 and 36 to 41 show the effect of overheating and high finishing temperature. Figs. 33 to 35 show what may be expected from a lower forging temperature and consequently lower finishing temperature. The absence of Widmannstättian structure in the high-power photomicrographs (Figs. 34 and 35) is noteworthy as compared with Figs. 31, 32, 37, 38, 40, and 41. This evidence of overheating is apparent

Fig. 41.—Detail of Fig. 45. Picric acid etch. × 90.

even after fairly prolonged heat treatment and is prevalent in the sorbite of bars that show flakes. Forging can be done at much lower temperatures and, where the reduction at the hammer is slight, there is no reason why the forging temperature cannot be kept as low as 1038° C. (1900° F.). It is possible that the defects which have caused a great number of forgings to fail to meet specifications might be traced to overheating in forging, temperatures in excess of 1371° C. (2500° F.) having been measured in furnaces in which ingots had been for as long as 8 hr. In this particular case, the bottom end of the ingot was in the hottest zone and records of the plant show 70 per cent. defective bars from this end of the forging compared with 46 per cent. in the other end of the forging, which

came from about half way up in the ingot. That these defects result from incipient fusion is a reasonable supposition. By reference to the carbon-iron diagram, the solidus at 0.40° C. (the steel in question was about 0.38 per cent. carbon and 3 per cent. nickel) is found to be not greater than 1340° C. (2444° F.), or 30° C. lower than the temperature observed above. Little has been done with the iron-nickel equilibrium diagram, but it is understood that nickel lowers the solidus line; therefore, more care must be taken with respect to the forging temperature of

FIG. 42.—FOR DESCRIPTION, SEE FIG. 45.

nickel steel, and successful forging of carbon steel does not imply that good forgings will follow the same practice with nickel steel. Once the steel has been heated above its solidus, small spots of fused metal will be formed throughout the steel where the concentration of carbon is greatest. At these points the original dendrites are at least partly destroyed and, upon forging, are drawn out between the adjacent dendrites, where they exist as burnt steel, forming lines of weakness and low ductility. That the damage which causes flakes is done after the ingot has been poured is indicated strongly by an experiment in which two ingots were cast from the bottom through a common runner; one ingot made a flaky forging and there was no trouble from this source in the other.

It must be remembered that, in cooling from the molten state through the Ar transformations, a very large grain size is set up with thick ferrite envelopes. No one would expect to obtain physical properties nor any fair degree of grain refinement to result from the heat-treating of ingot steel as cast. The structure does not respond, owing to the difficulty of getting the ferrite into solution. Very likely, in this case, the austenite is quite heterogeneous due to the slow diffusion of the ferrite from the thick boundaries of the original grains into the austenite grains formed in the pearlite, resulting in the grains that formed close to the ferrite

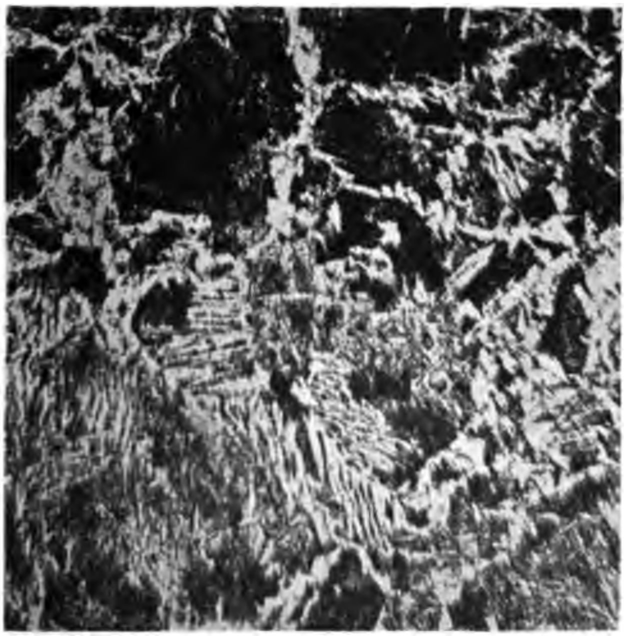

FIG. 43.—FOR DESCRIPTION, SEE FIG. 45.

envelope of the original grain being higher in iron content. This is the condition of the austenite that may exist upon reheating ingots for forging. In the case of a steel containing 0.38 per cent. carbon heating from below Ar, the first transformation will be that of the pearlite to austenite at Ac_1, followed by the absorption of the α iron envelope until at $Ac_{2,3}$ the envelope has disappeared. It does not necessarily follow, however, that austenite immediately below $Ac_{2,3}$ with its dissolved α iron is homeogeneous. In reheating steel of ingot structure, it is likely that the pro-eutectoid iron has not been able to penetrate to the grains of austenite formed at the interior of each of the grains that existed below Ac_1, so that there is still an envelope of iron-rich metal; nor will this heterogeneity end at $Ac_{2,3}$ with the transformation of the α iron into γ

when it enters the solid solution. Diffusion goes on in the austenite, but probably becomes complete only after a considerable length of time and, if the heating is carried to the solidus, there may still exist at that temperature spots of high carbon concentration in the center of what were the old grains of pearlite, these spots now existing as high-carbon austenite grains. These are the grains in which fusion will start and they will very likely be the austenite existing in the center of what were the largest of the original pearlite grains. As the temperature rises above the solidus, here and there throughout the steel there will be molten spots, their size

FIG. 44.—FOR DESCRIPTION, SEE FIG. 45.

depending on the temperature attained, surrounded by badly overheated metal, which upon forging will be drawn out flat. The forging may reclaim considerable of the overheated metal but the fused part will persist as films, having been the most plastic during the forging. Upon sorbitizing a steel in this condition, the part that has not been molten during the forging will have responded to treatment, whereas the films where the molten globules have been forged out have been only slightly affected, if at all. In a transverse test these two conditions will be apparent in a ductile, gray, fibrous fracture in which will appear a bright silvery area of low ductility, known as a flake. This bright area may consist of metal

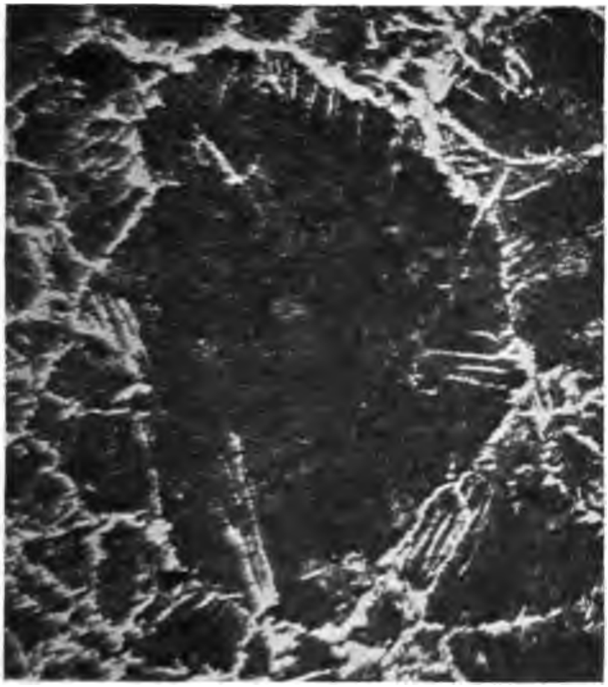

Fig. 45.

Figs. 42 to 45.—Coarse network of needle-like ferrite and sorbite. Typical structure of some forgings after improper heat treatment. Lack of uniformity in structure and the Widmannstättian structure noteworthy.

Fig. 46.—Surface of flaky steel after macroscopic etching and slight repolishing. Apparent cracks assumed to be flake areas eaten out by the acid. × 20.

in various conditions, ranging from burnt to only slight overheating. Severe treatment may reduce the size of the bright areas in so far as it is able to reclaim that part which has been overheated, but there will

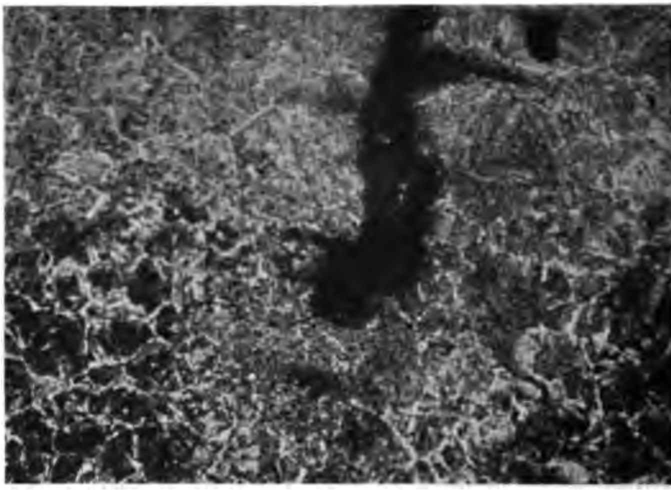

FIG. 47.—PORTION OF AREA SHOWN IN FIG. 46 AFTER REGRINDING AND ETCHING WITH PICRIC ACID. × 100.

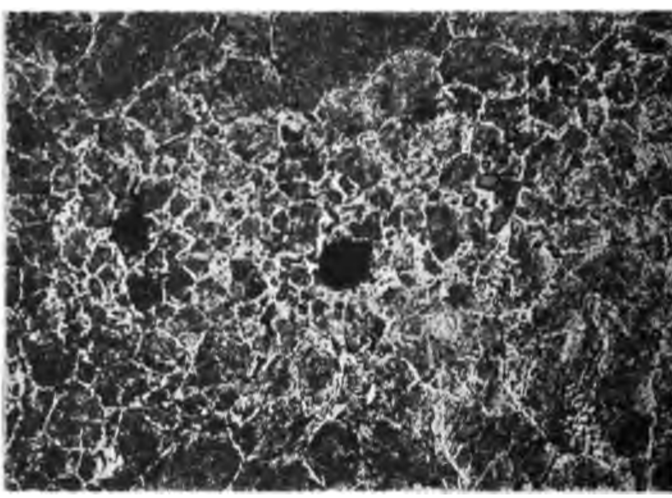

FIG. 48.—SPECIMEN OF FIGS. 46 AND 47 AFTER DEEPER GRINDING. PICRIC ACID ETCH. × 100.

always remain a part that has been fused, and this may never respond. The burning that produced this condition need not, and probably rarely does, become evident on the surface of the ingot for the reason that, in most cases, heating is done in an oxidizing atmosphere and the surface

of the ingot is decarburized, thus giving a coating of high melting point metal to the ingot.

It will be understood, from the foregoing hypothesis, that, in case of a

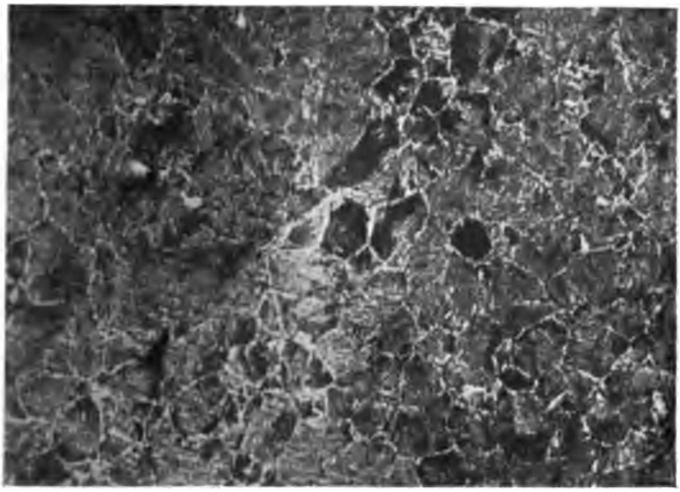

FIG. 49.—ANOTHER SPECIMEN OF SIMILAR METAL AFTER ETCHING WITH PICRIC ACID SHOWS AREA WHICH MANIFESTED ITSELF IN THE FRACTURE AS A FLAKE. × 100.

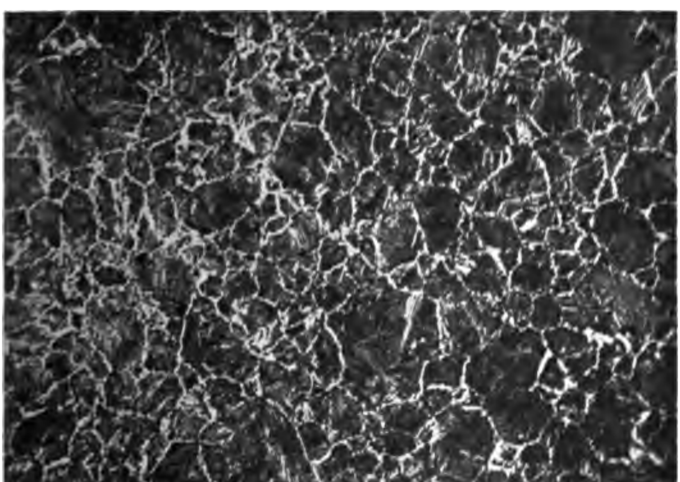

FIG. 50.—SPECIMEN OF METAL SIMILAR TO THAT IN FIGS. 46 TO 49, SHOWING MICROSTRUCTURE ASSOCIATED WITH FLAKY FRACTURE, ETCHED WITH PICRIC ACID. × 100.

heterogeneous austenite, one is not so much concerned with the solidus of the steel as a whole but with the solidus corresponding to that of the austenite of highest carbon content, which, in many cases, may be of

eutectoid composition. To get away completely from any possibility of this condition, forgings should not be heated to a temperature exceeding 1220° C. (2228° F.) and if a higher temperature is necessary great care should be exercised to see that the ingot is brought to the temperature slowly and well soaked out as the temperature rises, in order to permit of as much diffusion as possible.

The following attempt was made to efface flakes from material known to be very bad in this respect. Disks 15 in. (38 cm.) in diameter by 1¼ in. (3.18 cm.) thick with a 5⅜ in. (13.7 cm.) bore were obtained from each of two forgings that had been condemned for excessive flakiness. Each disk was cut along two diameters, making in all eight quadrants. These pieces were marked 948-A, B, C, and D and 986-A, B, C, and D, and all, except 948-C and 986-D and C, were treated. After treatment middle and inside test bars were machined out according to Ordnance Department specifications. The results are given in Table 2.

TABLE 2.—*Results of Tests of Condemned Forgings*

Piece No.	Treatment			Physical Properties				Position of Bar Tested
	Heated to Degrees C.	Held at Temperature, Hours	Cooled in	Tensile Strength, Pounds	Elastic Limit, Pounds	Elongation, Per Cent.	Reduction in Area, Per Cent.	
948-C	Untreated			80,530	54,770	3.0	10.0	Inside
				88,330	48,100	4.5	8.5	Middle
948-D	760	2	Water	93,140	71,610	6.5	17.5	Inside
	649	2	Furnace	93,760	78,570	4.5	16.5	Middle
948-B	815	2	Water					
	760	2	Water	96,220	65,560	6.5	13.0	Inside
	649	2	Furnace	94,870	65,430	7.0	14.0	Middle
948-A	871	2	Furnace					
	815	2	Water					
	760	2	Water	102,300	81,000	12.5	27.0	Inside
	649	2	Furnace	101,550	73,930	10.5	19.0	Middle
986-D	Untreated			88,000	53,500	5.0	10.0	Inside
				77,000	51,000	5.0	3.0	Middle
986-A	954	6	Air					
	760	4	Water	85,640	54,140	8.0	20.5	Inside
	649	3	Furnace	96,500	60,000	12.5	22.0	Middle
986-B	1024	2	Furnace					
	871	2	Furnace					
	760	2	Water	96,500	78,500	7.5	18.1	Inside
	649	2	Furnace	90,500	78,500	5.0	13.4	Middle

Analyses showed that the disks marked 948 contained 0.40 per cent. carbon, 0.62 per cent. manganese, 0.018 percent. phosphorus, 0.027 per cent. sulfur, 0.12 per cent. silicon, 2.99 per cent. nickel, and 0.14 per cent. chromium. The disks marked 986 contained 0.34 per cent. carbon, 0.55 per cent. manganese, 0.028 per cent. phosphorus, 0.019 per cent. sulfur, 0.10 per cent. silicon, 2.88 per cent. nickel, and 0.16 per cent. chromium. Pieces 948 showed a decided improvement in both

physical properties and flaking, the three heatings through the critical temperature giving the best results. Fig. 23 shows the condition as to flakes of disk 948–C; Fig. 24, the condition of disk 948–D; Fig. 25, the condition of disk 948–B; and Fig. 26, the condition of disk 948–A. The microstructure of 948–A is shown in Fig. 20; the dendritic structure in 948–C is shown in Fig. 27, and its persistence after treatment, in Fig. 28. There was no indication that heating to a higher temperature and holding for a long time at that temperature was of great benefit; this is apparent from results obtained in the case of pieces 986. The specifications called for a tensile strength of 95,000 lb., an elastic limit of 65,000 lb., an elongation of 18 per cent., and a reduction of area of 30 per cent.

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Die Castings and Their Application to the War Program

BY CHARLES PACK,* BROOKLYN, N. Y.

(New York Meeting, February, 1919)

Die castings may be defined as metal castings made by forcing molten metal, under pressure, into a metallic mold or die. It is necessary to keep this definition in mind to avoid confusing this process with other permanent-mold casting processes. The fundamental principles of the process have been known and practised many years. The simplest application is embodied in the modern linotype machine in which molten metal (usually tin-lead alloy) is forced under pressure into a metallic mold. The pressure is derived from a piston and cylinder immersed in the molten metal. Progress in the art of die casting may conveniently be divided into three groups: Machine for imparting pressure to the metal, material for the die or mold, casting alloys.

Casting Machines

The problem of delivering molten metal under pressure into a die is comparatively simple, when dealing with low-fusing-point alloys, as the alloys of lead and tin, but it is much more complicated when dealing with metals of higher fusing points, such as the alloys of zinc, aluminum, and copper. Although the art of die casting is comparatively new and, to a large extent, unknown, the records of the patent office are replete with patents on the subject.

Fig. 1 shows the Underwood machine patented in 1902; this is probably one of the first machines designed for the production of commercial die castings. The relation of this machine to the linotype casting machine is clearly apparent. A cylinder and piston are immersed in the molten metal, the application of power to this piston forcing the molten metal, under pressure, into the mold or die. The Doehler machine, Fig. 2, patented in 1907, is based on the same general principles. This machine is used to a large extent at the present time, throughout the United States, for the production of zinc, tin, and lead alloy die castings.

In the machine shown in Fig. 3, patented by Doehler in 1910, compressed air is used for forcing the metal into the die. In Fig. 4 is shown

* Chief chemist, Doehler Die Casting Co.

another of this type of machine. Here compressed air is applied to the surface of the molten metal to force it into the die.

In a machine patented by Chandler in 1914, shown in Fig. 5, the principle of the internal-combustion engine is applied for exerting pressure on the molten metal. A charge of gasoline vapor and air is injected into the melting chamber, the explosion of which forces the metal into the die.

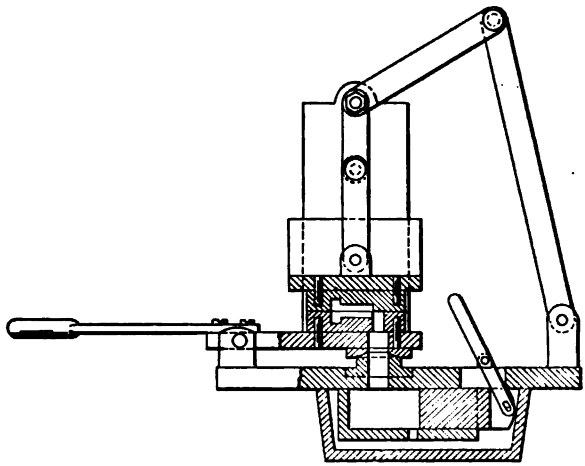

FIG. 1.—UNDERWOOD DIE-CASTING MACHINE.

The writer has never heard of this machine being used on a commercial basis, but it is mentioned to show the various means suggested for forcing molten metal into a die.

METHODS USED TO AVOID BLOW-HOLES

The fact that die castings are made under pressure would suggest, on first thought, dense and homogeneous castings; this impression, however, is not in accord with actual practice. On fracture, the pressure die casting will be found to consist of a dense closely grained outer stratum and a porous inner stratum. Blow-holes of varying size may be expected in the center of the die casting, particularly through heavy sections. Many machines have been designed with the primary object of overcoming this difficulty and producing solid die castings.

Fig. 6 shows an air-operated die-casting machine with the die inclosed in a vacuum chamber. The inventor evidently assumed that the only cause for blow-holes in the casting was the presence of air in the die. In Fig. 7 is shown another die-casting machine in which the vacuum principle is applied; here the vacuum is applied directly to the die.

The production of die castings free from blow-holes has been the most serious problem confronting die-casting manufacturers. At various

times it has been stated that processes capable of producing solid and homogeneous die castings have been developed. If all blow-holes in die castings were caused by air coming in contact wth metal, the vacuum process would deserve consideration. That the presence of blow-holes in some die castings are due to other and more serious causes, the writer will endeavor to prove.

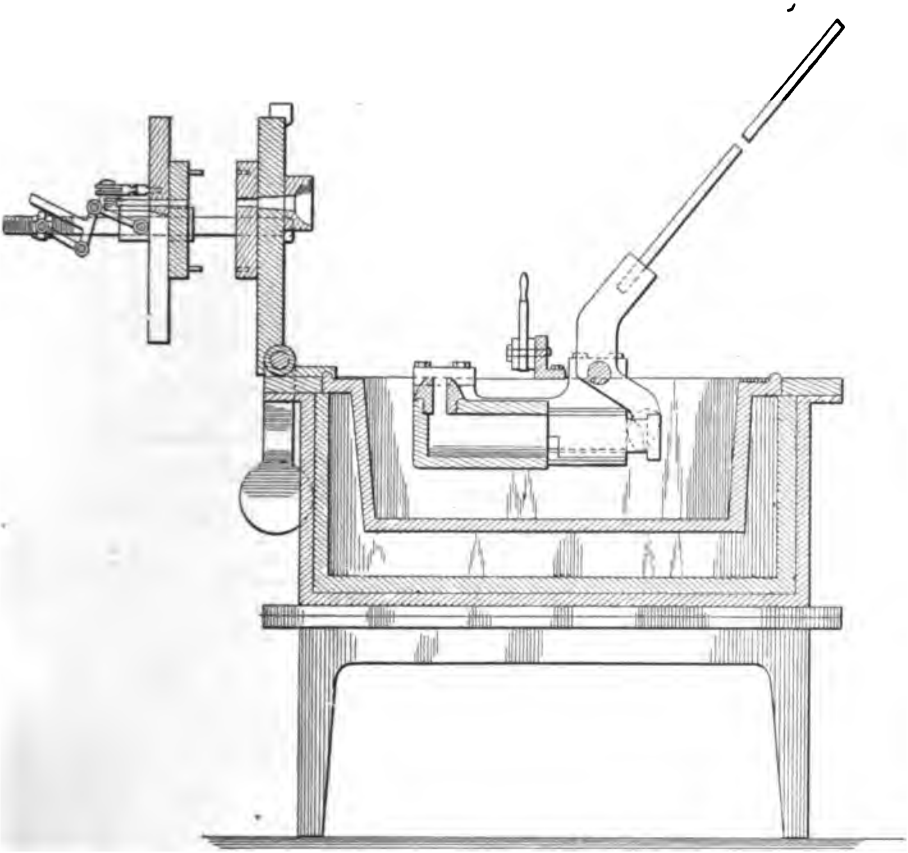

FIG. 2.—EARLY TYPE OF DOEHLER MACHINE.

In Fig. 8 is shown a cross-section of a casting that can be gated at *A* or *B*; in the best foundry practice the gate *A* would probably be used. The first metal that goes into the die will chill around the inner walls and take the form shown in the shaded portion. The gate may then become chilled before the inner portion has been filled; this will cause blow-holes that no vacuum will eliminate. A similar effect will be produced if the metal was too cold at the time of casting. The writer has produced castings having only an outer shell, similar to that shown in Fig. 8, by limiting the amount of metal injected into the die to a quantity less

than that required to make the casting. A similar result may be obtained by running the metal so cold that it will chill the thinner sections of the casting before the heavier sections are completely filled. Lack of pressure will produce the same result.

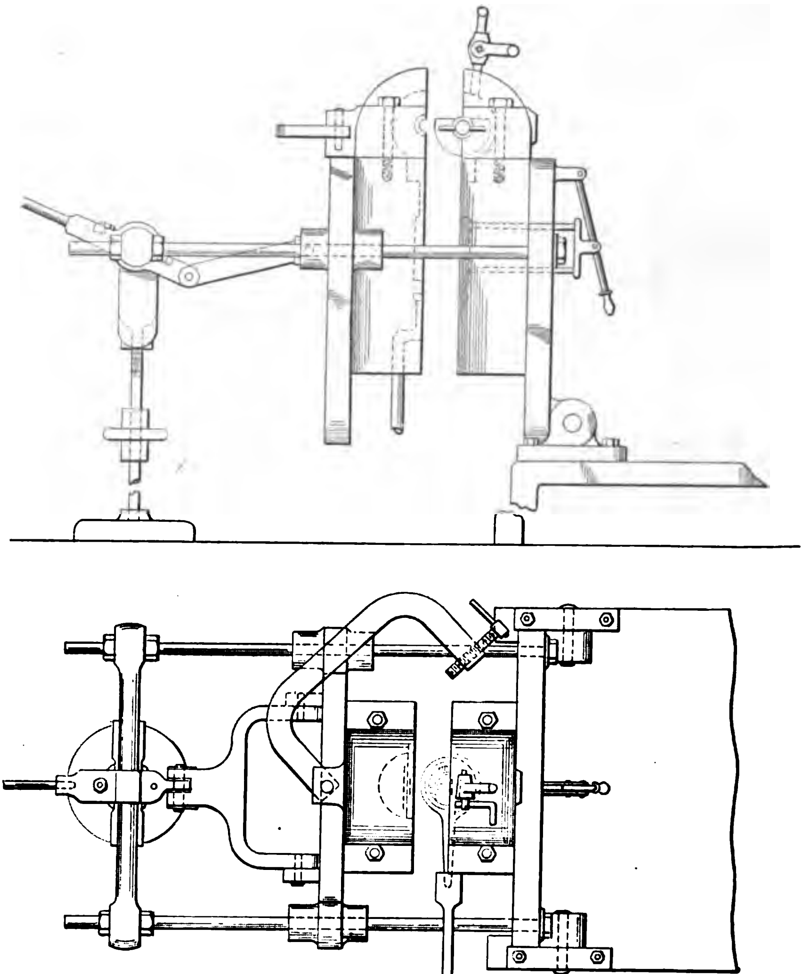

FIG. 3.—DOEHLER COMPRESSED-AIR MACHINE.

Blow-holes in die castings may also be caused by the phenomenon that we sometimes call "piping." Makers of rolling-mill ingots have often been confronted with this problem. In Fig. 9 is shown cross-section of another casting gated at A. The metal flowing into the die at A will fill the entire mold cavity, assuming all casting conditions to be ideal, but the metal in the thin section adjoining A will chill before the heavier

section so that, the chilling being from the outside, a shrinkage hole will be left in the center. Here again no advantage can be gained by the use of the vacuum system.

Dies

In the manufacture of die castings from zinc, tin, and lead alloys, dies made from low-carbon machine steel last almost indefinitely and answer every purpose. In the first attempts to die-cast aluminum,

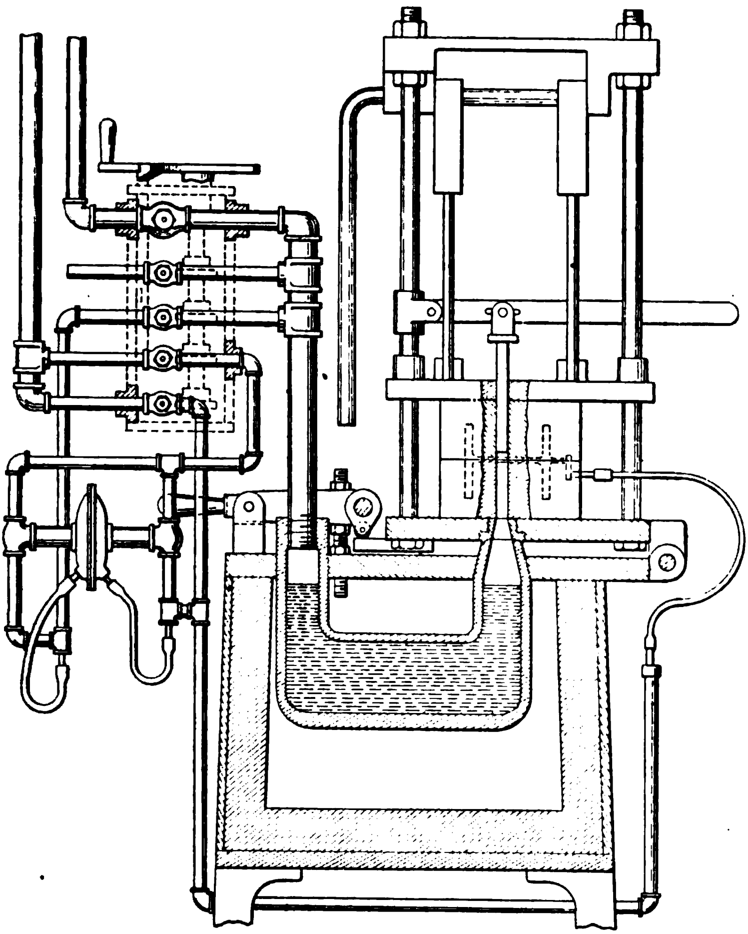

Fig. 4.—Another type of compressed-air machine.

the problem of obtaining a suitable die material presented serious difficulties, which were described by the writer in a paper read before the American Institute of Metals in 1915. This problem, however, has been solved by the use of various alloy steels making possible the com-

mercial die casting of aluminum and its alloys, which constitutes the greater part of the die-casting industry of today. The proper gating and venting of these dies are problems that arise daily and on the solution of these problems depends the success or failure of the process.

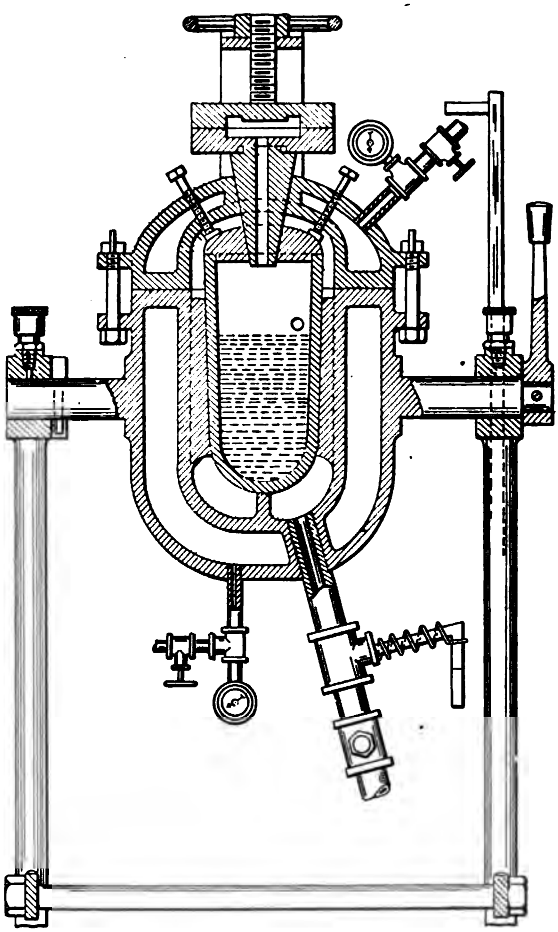

FIG. 5.—CHANDLER DIE-CASTING MACHINE.

ALLOYS

In a paper read before the American Institute of Metals in 1914, the writer described the various types of zinc, tin, and lead alloys used in the die-casting process. The application of these alloys and their limitations were also pointed out. At that time the die casting of aluminum and its alloys was barely beyond the experimental stage. During the past 4 years, the most important advance in the art of die casting has been made in the perfection of the process for die-casting aluminum and

its alloys. The importance of this achievement as an aid to winning the war is best demonstrated by the fact that at least 95 per cent. of the die-cast parts used directly or indirectly as materials of war were made from an aluminum-base alloy. Of these castings, only a very small percentage could have been produced successfully in 1914.

Investigations of the casting properties of metals and alloys in the past have been generally limited to sand castings; few data are available as to the casting properties of metals or alloys in metallic molds. Just what constitutes a good die-casting alloy is a subject of unusual interest. A few of the important requirements, outside of the usual physical properties demanded of alloys, are:

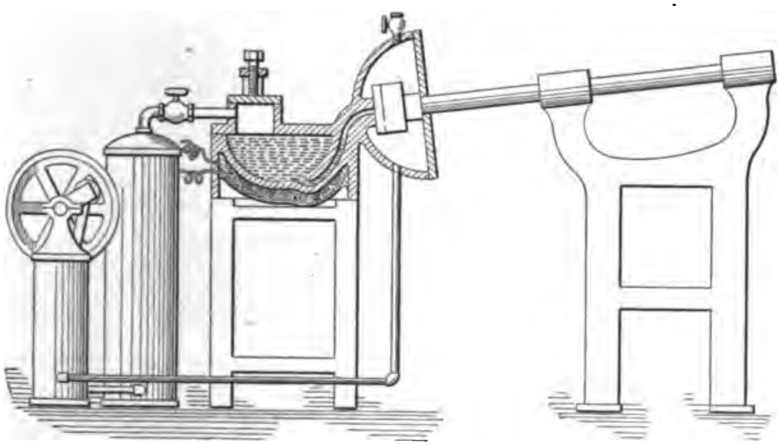

FIG. 6.—MACHINE WITH DIE ENCLOSED IN VACUUM CHAMBER.

Melting Point.—The successful die-casting machine in every instance is constructed of iron, in one form or another. The melting point of the alloy must be such that it will melt readily in an iron pot.

Solvent Action.—The solvent action of the alloy on iron must not be too great. Molten aluminum dissolves iron very rapidly and analyses of aluminum die castings on the market will show an iron content of from 1 to 3 per cent., due to the solvent action. Fortunately, there is no serious objection to the presence of iron in aluminum casting alloys. Should the aluminum absorb much above 3 per cent. iron, the melting point becomes too high and the alloy becomes viscous and unsuitable for making castings.

Elongation.—The elongation of the metal is of vital importance in determining the die-casting properties of an alloy. Not only is it desirable to know the elongation of the alloy when cold, but it is of greater importance to determine the elongation at various temperatures ranging from the melting point of the alloy down to normal tem-

perature. The reason for this becomes apparent when the physical phenomena of the die-casting process are considered. Let us assume that a ring 12 in. (30.48 cm.) in diameter is to be die-cast in a metallic mold around a metallic core. As the molten metal strikes the mold it solidifies. Here a change of state occurs that is accompanied by a reduction in volume, commonly termed shrinkage. Unlike a sand core, the metallic core is not compressible and retains its original size and form so that the shrinkage of the metal is converted into a stretching action on the solidified casting. If the elongation of the alloy at that temperature is not high enough to withstand this stress the casting will crack. In the usual die-casting practice it is not

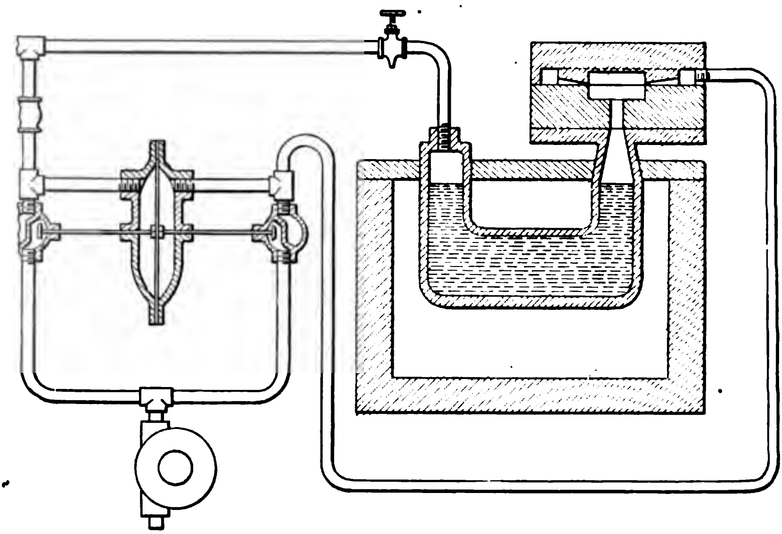

FIG. 7.—DIE-CASTING MACHINE WITH VACUUM APPLIED DIRECTLY TO DIE.

practical to remove the casting from the die at the solidification temperature of the alloy. For example, the solidification temperature of the aluminum-copper alloys used in the die-casting process is approximately 1150° F. (621° C.). It has not been found practical to run the casting dies above a temperature of 500° F. (260° C.), which means that the castings are withdrawn from the dies at that temperature. It follows that the casting is subjected to another stretching stress after the casting has solidified, due to the contraction in volume that must occur when a casting is cooled from a temperature of 1150° F. to 500° F.

The writer has been unable to find any reliable method for determining quantitatively the elongation of alloys at various temperatures. Many methods have been suggested but they have proved of doubtful value. The simplest way is to use the old "try-and-see" method. To

test the alloy, a casting is made in a die having a comparatively large core and thin wall. If the alloy can stand the casting stress, a perfect casting will be obtained, otherwise the casting will show bad cracks. Only a comparative result is obtained, but for everyday control it answers the purpose. However, a simple and reliable method for determining quantitatively the elongation of metals and alloys at various

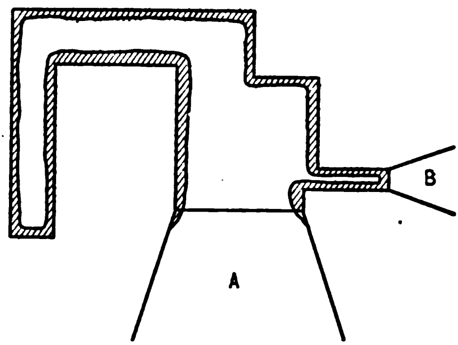

FIG. 8.—CROSS-SECTION OF CASTING WITH TWO GATING POSITIONS.

temperatures would prove of enormous value to all metallurgists engaged in the various phases of metal-casting research.

It is interesting to note that the elongation of a metal or alloy at normal temperatures is no indication as to the properties of that metal or alloy at higher temperatures. The writer has found many cases where an alloy showing little or no elongation at normal temperatures shows a high elongation at higher temperatures. The alloys of aluminum and

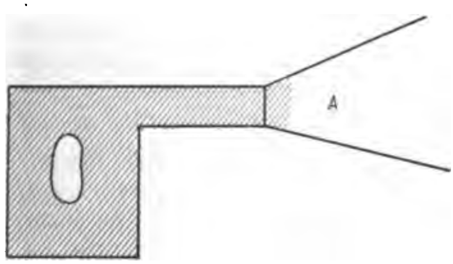

FIG. 9.—DIE CASTING CONTAINING SHRINKAGE HOLE.

copper may serve to illustrate this point. It is well known that the addition of copper to aluminum reduces the elongation of the aluminum alloy. An aluminum alloy containing 12 per cent. copper will show less elongation than an alloy containing only 6 per cent. copper when tested at normal temperatures. Nevertheless, the 12 per cent. copper alloy has a greater elongation at higher temperatures than the 6 per cent. alloy

and consequently the 12 per cent. alloy is better able to withstand the casting stresses to which it is subjected in the die-casting process.

In the early days of the die-casting industry, alloys were compounded indiscriminately and little or no consideration was given to the metallurgical principles involved. The manufacturer in many instances knew much more about machinery than about metals. The result was that there were put on the market die castings made from alloys that deteriorated rapidly and created a prejudice among engineers against the use of these castings. That this prejudice was in part justified must be admitted; nevertheless, the modern die-casting plant is equipped with physical and chemical testing laboratories and the die-casting practice of today bears no relation to that of 5 years ago.

Die Castings Made for War Purposes

Die castings have had their most severe test during the past 2 years, during which time most of the die castings manufactured were used directly, or indirectly, in the Government's war program. Here is a partial list of the application of die castings for this purpose.

Gas masks, breather tubes and other metal parts.

Lewis machine guns, 100 die-cast parts to every gun.

Browning machine guns, four of the most vital parts.

Naval and army binoculars, the entire housing.

Army truck, tank, and airplane die-cast parts include parts of ignition system, carburetor, gasoline-regulating devices, steering-wheel accessories, ball-bearing cages, bearings, speed indicators, etc.

Pistol, complete signal pistol.

Submersible bombs, some designs contained as many as 10 die-cast parts.

Hand and rifle grenades, every grenade manufactured in this country contained one or more die castings.

Trench mortar shells, plugs die cast.

Airplane drop bombs, one or more die-cast parts.

Surgical instruments, including hair clippers, respiratory devices, etc.

In many instances, die-cast parts were used where the failure of the part would result in serious loss of life. The fact that not one failure of a die casting has been reported must continue to be a source of deep satisfaction to the modern die-casting manufacturer.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Anthracite Mining Costs

BY R. V. NORRIS,* E. M., M. SC., WILKES-BARRE, PA.

(New York Meeting, February, 1919)

It was stated in a former paper[1] that an intensive study of anthracite costs was being made by the engineers of the United States Fuel Administration. The results of this study are now available and are offered as a supplement to the former paper.

Anthracite costs as reported for the 6-months period, December, 1917, to May, 1918, inclusive, as compiled by the Federal Trade Commission, were used as a base, and charts similar to those described in the former paper were made for the standard white ash anthracite and for red ash and Lykens valley coals.

Adjustments

The adjustments of cost from a reported to a price-fixing basis, as described for the bituminous methods, were applied but showed only minor adjustments as necessary.

The great spread in anthracite prices on the varying sizes, which for the 6-mo. period under review ranged in average from $5.244 for nut to $2.074 for barley coal, makes the question of the percentage of sizes produced at the different collieries a vital one. The realization with the same prices for each size must be within very wide limits, when it is considered that the percentage of prepared coal reported from different collieries varied from over 80 per cent. to below 30 per cent. for fresh-mined coal. Hence, as the spread in prices for the various sizes must be predicated on some percentage, it is essential to find some method of adjustment to allow for this variation. The logical method of adjustment is to calculate actual costs to costs as of the standard percentage of sizes, so that the margin between the adjusted costs and the average realization shall be the actual margin for each colliery between its actual costs and actual realization due to its particular percentage of sizes. As a base for realization the actual percentage of sizes for fresh-mined coal for the 6-mo. period was adopted. This percentage is given in Table 1.

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* Engineer, U. S. Fuel Administration.

[1] Cyrus Garnsey, Jr., R. V. Norris and J. H. Allport: Method of Fixing Prices of Bituminous Coal Adopted by the United States Fuel Administration. *Bull.* 141 (Sept., 1918) 1411.

TABLE 1.—*Percentage of Sizes of Fresh-mined Coal*

Size of Coal	Mesh, in Inches				Percentage of Sizes		
	Through		Over		Fresh Mined	Washery	Fresh Mined and Washery
	Square	Round	Square	Round			
Broken	4	$4\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{1}{4}$	6.8	0.4	6.2
Egg	$2\frac{3}{4}$	$3\frac{1}{4}$	2	$2\frac{5}{16}$	14.6	1.2	13.5
Stove	2	$2\frac{5}{16}$	$1\frac{1}{2}$	$1\frac{11}{16}$	19.6	2.3	18.2
Nut	$1\frac{1}{2}$	$1\frac{11}{16}$	$\frac{3}{4}$	$\frac{15}{16}$	24.7	10.1	23.5
Pea	$\frac{3}{4}$	$\frac{15}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	9.1	10.0	9.2
Buckwheat	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{5}{16}$	$\frac{7}{16}$	11.6	21.4	12.4
Rice	$\frac{5}{16}$	$\frac{7}{16}$	$\frac{3}{16}$	$\frac{1}{4}$	3.2	14.9	4.2
Barley	$\frac{3}{16}$	$\frac{1}{4}$		$\frac{3}{32}$	4.9	27.5	6.8
Boiler	$\frac{1}{2}$	$\frac{5}{8}$		$\frac{3}{32}$	3.9	8.8	4.3
Screenings		$\frac{3}{32}$		$\frac{3}{64}$	1.6	3.4	1.7

For adjustment as a base for fixing a spread of prices the percentages used were, taken at even figures, prepared 65 per cent., pea 9 per cent., buckwheat 12 per cent., and smaller 14 per cent.

The adjustment finally arrived at after long study was tested on actual reports from collieries having percentages that varied from over 80 per cent. to under 30 per cent. prepared coal and was found to be correct within a maximum variation of less than $1\frac{1}{2}$ per cent. It was as follows:

ForEach 1 Per Cent. Variation	Above Standard, Per Cent. Deduction	Below Standard, Per Cent. Addition
Prepared	1.20	1.20
Pea	0.85	0.85
Buckwheat	0.75	0.75
Smaller	0.50	0.50

As examples of the working of this adjustment with prices assumed at about the average for the 6 mo. and taking mines well away from average percentage of sizes.

Size	Base Per Cent. Sizes	Base Price	Realization	Mine A, Per Cent. Sizes	Correction, Per Cent.	Actual Realization	Mine B, Per Cent. Sizes	Correction, Per Cent.	Realization
Prepared	65	$5.10	$3.315	73.1	−9.72	$3.730	55.1	+11.880	$2.810
Pea	9	3.70	0.333	6.4	+2.21	0.237	15.3	− 5.355	0.566
Buckwheat	12	3.20	0.384	10.4	+1.20	0.333	13.7	− 1.275	0.438
Smaller	14	2.20	0.308	10.1	+1.95	0.222	15.9	− 0.950	0.350
Totals	100		$4.340	100.0	−4.36	$4.522	100.0	+ 4.30	$4.164

	Mine A		Mine B
Assume cost for each mine	$4.000		$4.000
Actual margin	$0.522		$0.164
Standard realization	$4.340		$4.340
Calculated cost as of standard per cent. sizes $4.00 × 0.9564% =	$3.826	$4.00 × 104.30% =	$4.172
Calculated margin	$0.514		$0.168

The correction for Mine A is then −4.36 per cent. and the adjusted cost \$3.826, showing 51.4 c. margin on the \$4.34 standard realization against 52.2 c. actual margin. Similarly for Mine B, the correction is +4.30 per cent., giving an adjusted cost of \$4.172 and a margin of 16.8 c. as compared with the actual margin of 16.4 c. Thus the adjusted costs on the chart bear a true relation to the realization received from a scale of prices for the various sizes based on the standard or average percentage of sizes adopted as a base, regardless of the actual percentage of sizes produced by each operation, and prices can be fixed from the chart line of adjusted costs which will result in giving each mine its intended margin. The correction, of course, is an allocation based on realization from the different sizes and could be made more accurately by taking into account each size produced, but at the cost of more time than was available for the work. With a material variation in price, different factors of correction should be calculated.

Royalties

A large percentage of the anthracite coal is owned in fee by operators, who also lease tracts contiguous to their fee holdings. As all report royalties on the basis of tonnage produced, the general average 15.5 c. per T. reported is misleading. The actual average royalty reported by operators mining generally from leased lands was 33.25 c., and by those generally mining from fee lands, 5.5 c. As relatively few operators mine exclusively from either class of lands, no data is available to show the actual average royalties paid, but it is believed that the present average would be approximately 40 c. per ton.

A few leases, notably those made by the trustees of the Girard Estate, owned by the City of Philadelphia, base the royalty payments on a percentage of the sale price of the coal at the mines instead of requiring fixed royalties; this percentage varies from 15 per cent. to as high as 28 per cent. of the price. As the labor war bonuses materially add to the sale price, these have resulted in excessive royalties and serious embarrassment to the operators, who were not allowed to increase the price of coal sufficiently to even fully absorb this additional labor cost and by whom the extra royalties must be paid out of already narrow margins. Many of the lessors have patriotically foregone the extra royalties due under these sliding scales, and as it is certainly improper that the public should be asked to pay these additional royalties, not contemplated in the original contract though enforceable at law, the U. S. Fuel Administrator has expressed himself as unwilling to consider such excess payments in any fixing of anthracite prices.

Cost Charts

Cost charts were made from averages of the 6 mo., showing both the reported and the adjusted costs for standard fresh-mined white ash

anthracite, both by collieries and by operating companies. As, in the prices fixed by the President, Aug. 23, 1917, a differential of 75 c. per T. on pea size and above, equivalent to 52.95 c. per T. on all sizes, was established for the independent operators over certain companies with railroad affiliation, generally known as the "Companies" charts were made by collieries for both the independent operators and the Companies, as well as a combined chart of the entire output. Similar charts were also made for the entire output of fresh-mined coal and for the total output

TABLE 2.—*Average and Bulk Line Costs of White Ash Coal*

Chart Number	Description	Costs, Averages Returned	Costs, Adjusted	Cost, 90 Per Cent. Bulk Line
	EXCLUDING WASHERY COAL			
81	All operations, each colliery separate...	$3.85	$3.91	$4.80
82	All company operations, each colliery separate..........................	3.71	3.79	4.65
83	All independent operations, each colliery separate..........................	4.37	4.36	4.97
86	All operations, each company operating two or more collieries consolidated.....	3.85	3.91	4.38
91	INCLUDING WASHERY COAL			
	All operations, each company operating two or more collieries consolidated...	3.57	3.77	4.36

TABLE 3.—*Average Prices Received for White Ash Coal*

Size	Fresh Mined Coal		Bank Coal		Total Including Banks	
	Per Cent.	Average Price	Per Cent.	Average Price	Per Cent.	Average Price
Broken................	6.8	$4.889	0.4	$4.416	6.2	$4.886
Egg................	14.6	5.028	1.2	4.815	13.5	5.027
Stove................	19.6	5.161	2.3	5.060	18.2	5.160
Nut................	24.7	5.244	10.1	5.246	23.5	5.244
Pea................	9.1	3.687	10.0	3.696	9.2	3.698
Total and weighted av'g prepared and pea......	74.8	4.959	24.0	4.544	70.6	4.947
Buckwheat............	11.6	3.342	21.4	3.213	12.4	3.324
Rice................	3.2	2.482	14.9	2.452	4.2	2.473
Barley................	4.9	2.231	27.5	1.767	6.8	2.074
Boiler................	3.9	2.341	8.8	2.123	4.3	2.304
Screenings............	1.6	2.202	3.4	1.555	1.7	2.162
Total and weighted av'g small sizes............	25.2	2.795	76.0	2.339	29.4	2.697
Grand total............	100.0	4.414	100.0	2.868	100.0	4.285

including washery coal by operating companies, all collieries operated by a single company being consolidated. Similar charts were made for red ash and for Lykens valley coal. These charts were interesting princi-

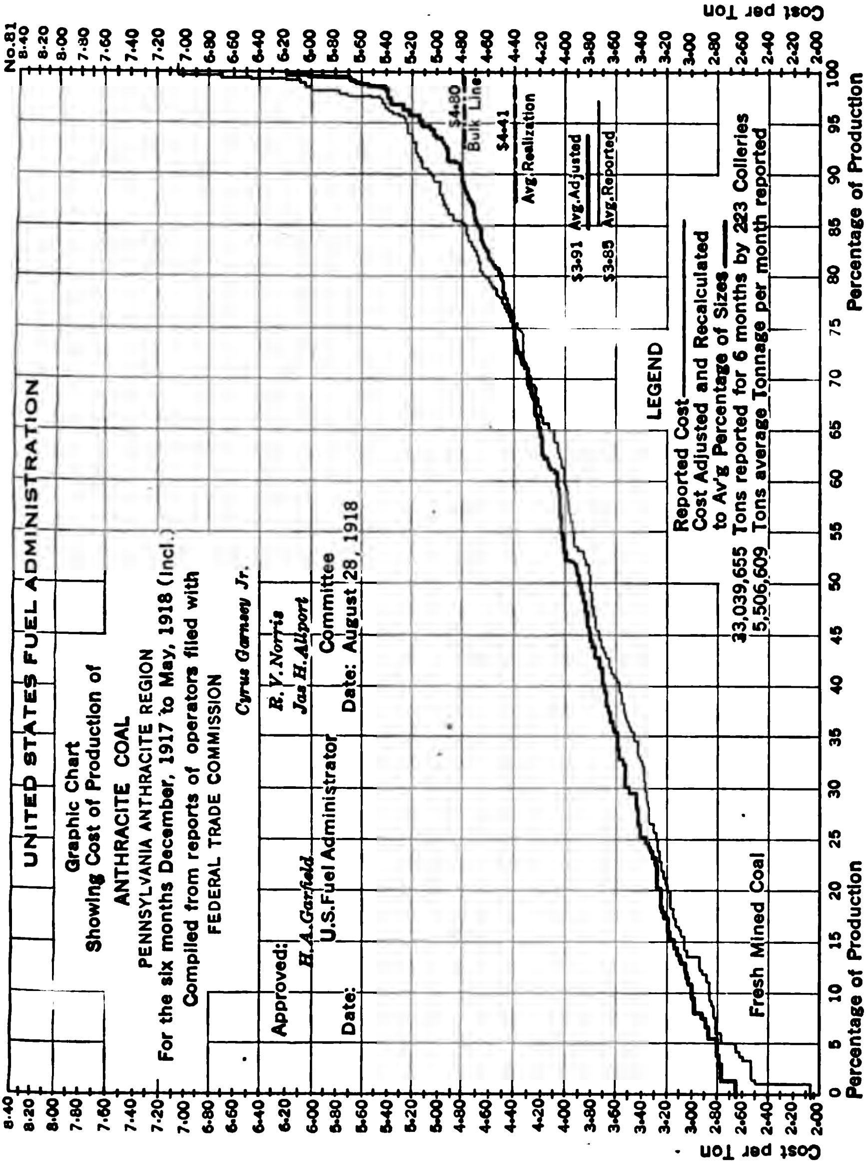

FIG. 1.

pally in that they showed that the higher prices charged for these specialties were justified by their higher costs of production. The charts given are believed to fairly show the general costs of production.

These charts show the averages and bulk line costs for standard white ash coal given in Table 2. The average prices received are given in Table 3.

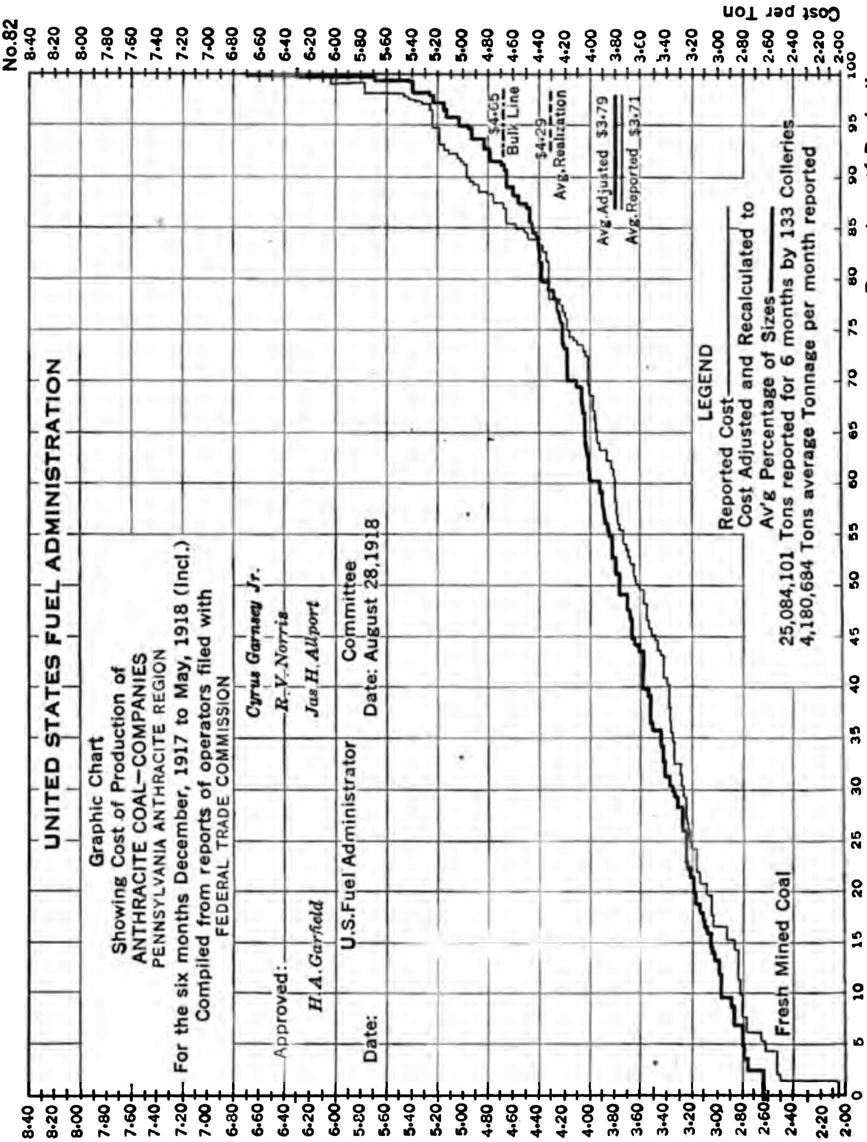

Fig. 2.

The prices received by the Companies and Independents have not been separately averaged, but calculating on the differential and assuming

the percentages the same for Companies and Independents, which is only approximately the case, the selling price of fresh mined coal would average for Companies, $4.287 and for Independents, $4.817. Margins over reported costs of Companies would be 58 c. and for Independents 45 c.

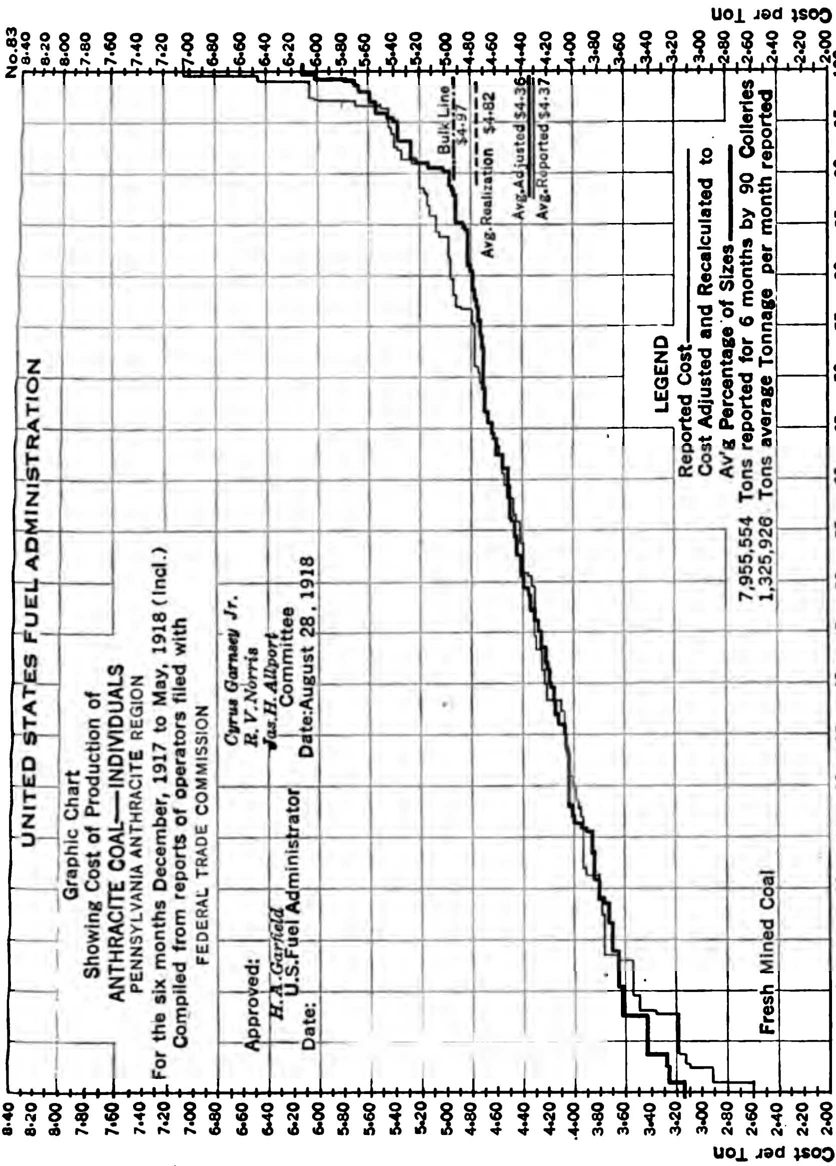

FIG. 3.

with a general average margin for all fresh-mined coal of 56 c. and for all coal including washery of 71 c. per T., and under "bulk line" costs

fresh-mined Companies, 36 c.; Independents, 15 c.; total, 39 c.; including washeries consolidated sheets total of 7.5 c.

These margins include all expenditures for Federal income and excess profits, taxes, selling expenses, interest charges, expenditures for

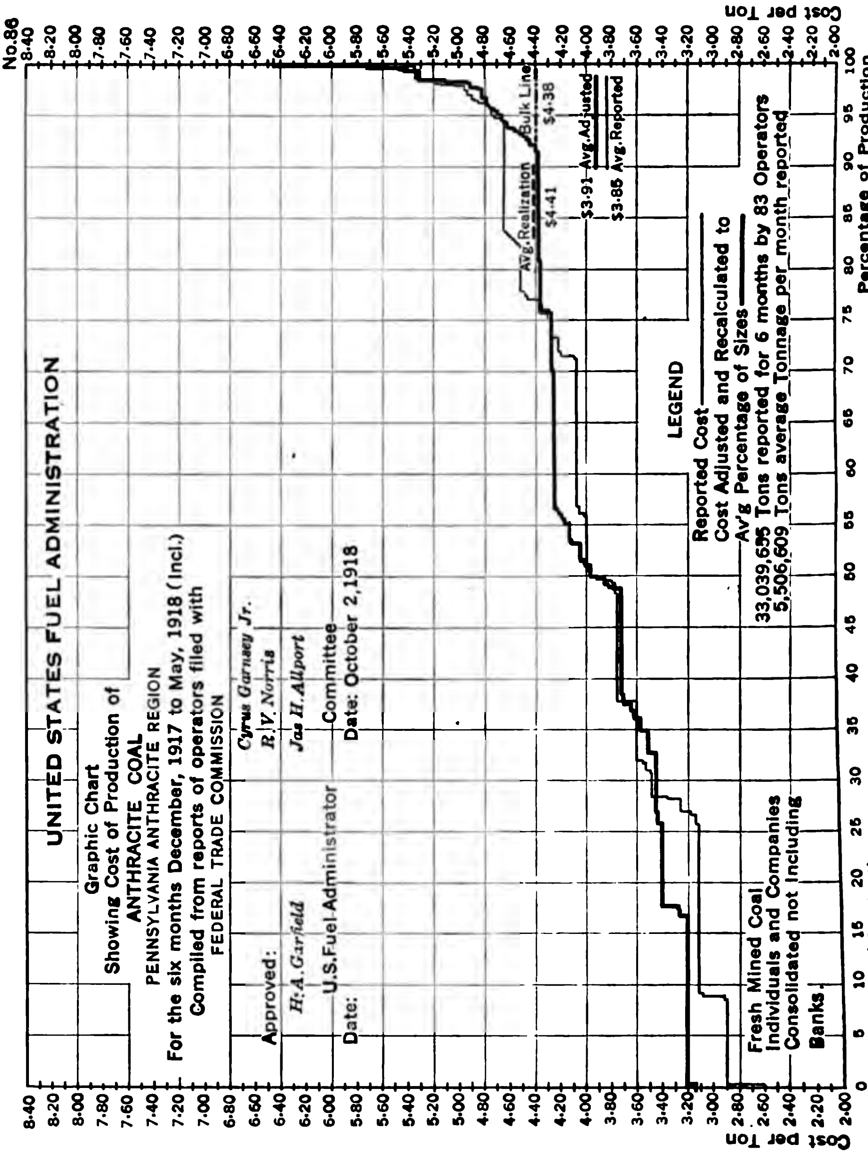

Fig. 4.

improvements and developments to increase output, excess of capital expenditures over normal cost, and all profit on the investment of about $8 per ton annual output.

Labor Increases

Effective Dec. 1, 1917, a labor war bonus, ranging from 60 c. to $1.10 per day for labor and 25 per cent. for contract miners was granted, and

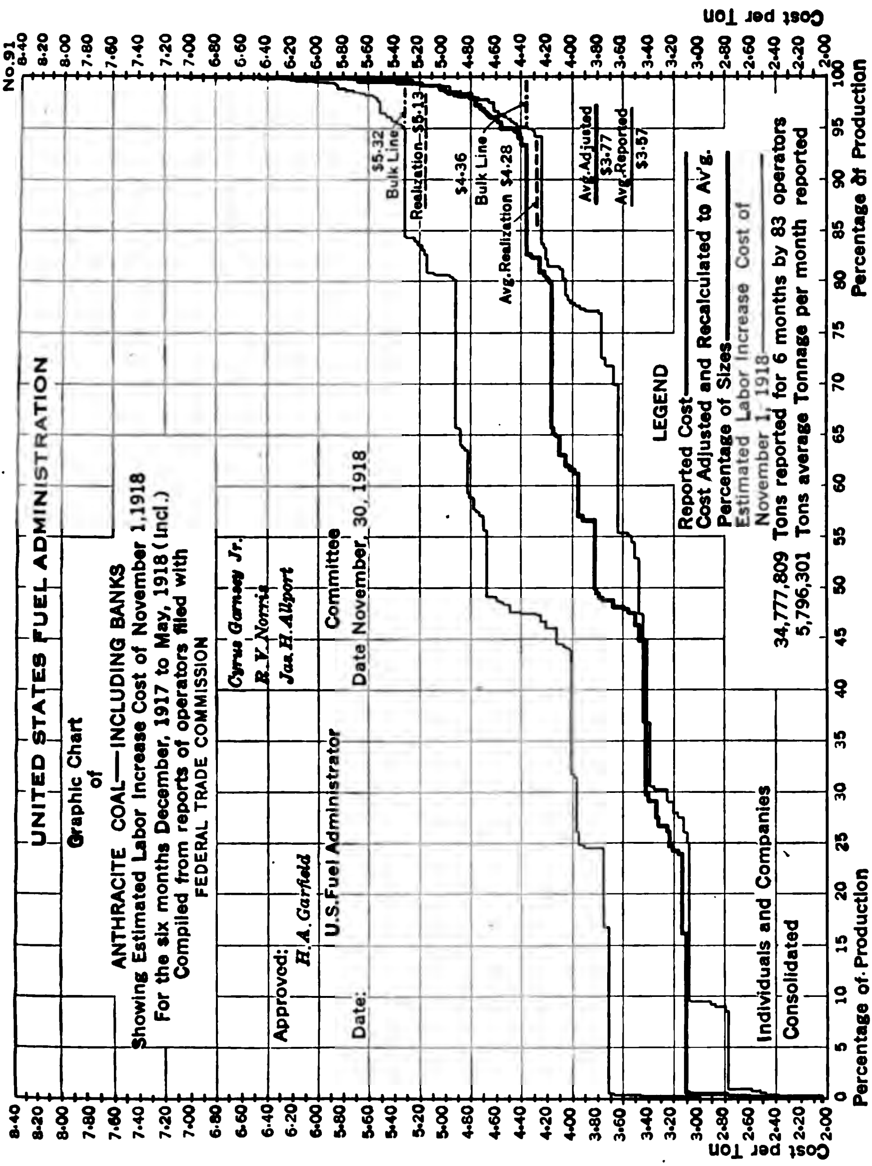

Fig. 5.

the prices fixed Aug. 23, 1917 and modified Oct. 1, 1917, by reducing pea coal 60 c. per T., were increased by 35 c. per T. to compensate for this labor increase. The actual reported increase in labor cost due to this

advance was figured by the Federal Trade Commission from the operators' reports to be 60.3 c. From the actual payroll figures later obtained by the U. S. Fuel Administration, this increase was found to be 76.3 c. per T.

Effective Nov. 1, 1918, a second labor war bonus was granted. The calculated increase in cost due to this is shown in Fig. 5, on which the increases for each operator are found by figuring from the payrolls, for the 6 mo., the actual increase in pay which would have been given applying the Nov. 1, 1918, increases, and dividing by the 6 mo. tonnage of the colliery. This line, adjusted to per cent. of sizes, plotted on the chart shown in Fig. 5 and compared with the adjusted cost, shows an increase in cost of 74.1 c. As this was necessarily applied to the prepared and pea sizes 70.6 c. of the total the increase on these sizes was $1.05 per T., which increase was allowed to balance the increased cost of labor.

Price Fixing

Except for the two increases to compensate for labor increases just noted and the reduction, Oct. 1, 1917, of the pea coal price, the anthracite prices are as fixed by the President on Aug. 23, 1917. The present realization, all companies and all sizes, including washery coal and both the labor increases, is calculated to average $5.13 per T., while the bulk line

Table 4.—*Prices Fixed by the President, Aug. 23, 1917*

	White Ash		Red Ash		Lykens Valley	
	Company	Independent	Company	Independent	Company	Independent
Broken	$4.55	$5.30	$4.75	$5.50	$5.00	$5.75
Egg	4.45	5.20	4.65	5.40	4.90	5.65
Stove	4.70	5.45	4.90	5.65	5.30	6.05
Chestnut	4.80	5.55	4.90	5.65	5.30	6.05
Pea	4.00	4.75	4.10	4.85	4.35	5.10

Table 5.—*Fixed Prices, Dec. 31, 1918*

	White Ash		Red Ash		Lykens Valley	
	Company	Independent	Company	Independent	Company	Independent
Broken	$5.95	$6.70	$6.15	$6.90	$6.40	$7.15
Egg	5.85	6.60	6.05	6.80	6.30	7.05
Stove	6.10	6.85	6.30	7.05	7.10	7.85
Chestnut	6.20	6.95	6.30	7.05	7.10	7.85
Pea	4.80	5.65	4.90	5.75	5.15	5.90

of the chart shown in Fig. 5, plus the November, 1918, labor increase would be $5.32.

Capital Investment

The capital invested per ton output in the larger and better equipped collieries ranges from $5 to $11, with an average investment from $7.50 to $8.

Prices Fixed

The prices fixed by the President Aug. 23, 1917, are given in Table 4. No price was fixed on sizes smaller than pea, which was decreased 60 c. per T. Oct. 1, 1917. There was a general increase of 35 c. per T. Dec. 1, 1917 and one of $1.05 per T. Nov. 1, 1918. Sizes smaller than pea were limited to a maximum 50 c. per T. below pea coal by order of Nov. 15, 1918.

Table 6.—*Average Cost, December*, 1917, *to May*, 1918

	Fresh Mined Coal, 35,256,550 T. Cost per Ton	Washery Operations, 3,431,916 T. Cost per Ton	Total Including Washeries, 38,688,466 T. Cost per Ton
Labor	$2.593	$0.687	$2.423
Supplies	0.616	0.260	0.584
Transportation, mine to breaker	0.004	0.007	0.004
Royalty, current	0.153	0.102	0.148
Royalty, advance	0.002		0.002
Depletion	0.099	0.077	0.097
Amortization of cost of leasehold	0.014	0.024	0.016
Depreciation	0.091	0.086	0.090
Pro rata suspended cost of stripping	0.023		0.021
Contract stripping and loading	0.009		0.009
Taxes, local	0.054	0.034	0.079
Insurance, current	0.016	0.014	0.016
Insurance, liability	0.058	0.018	0.055
Officers' salaries and expenses	0.030	0.019	0.029
Office salaries and expenses	0.048	0.024	0.045
Legal expenses	0.005	0.003	0.005
Miscellaneous	0.026	0.023	0.026
Total	$3.871	$1.398	$3.651
Increase over May to November, 1917	$0.764	$0.365	$0.719

The present fixed prices, Dec. 31, 1918, per ton of 2240 lb., f.o.b. mines, are given in Table 5. Smaller than pea is not to be sold within 50 c. of maximum pea-coal price. Thus the selling price of anthracite has been increased but 30.5 per cent. over the pre-war price, while the cost of production has gone up 52 per cent., the difference having been absorbed by the operators.

The average cost as reported for the 6 mo., December, 1917, to May, 1918, inclusive, prior to the increase of Nov. 1, 1918, but including that of Dec. 1, 1917, is given in Table 6.

Accounting Suggestions

Depletion of Lands.—No standard practice in charging off depletion was found. The charges to this account varied, even among the larger operators, from nothing or a nominal fraction of a cent per ton to practically the full royalty rate. The proper charge for depletion is admittedly a difficult question. Under the present (1917) income-tax law, lands purchased since Mch. 1, 1913, may be depleted to return the cost price on exhaustion, and lands purchased before that date may be depleted on their value as of Mch. 1, 1913. The second class may be again divided into those operated on royalty by others than the owners, where the depletion accrues to the owners, and to those lands directly operated by the fee owners.

In the case of royalty lands, the value as of Mch. 1, 1913, is clearly the present value as a varying annuity of the annual amount of the royalties for the term of the life of the property, and as this sum is not dependent on the vicissitudes of mining, the discount is properly at the going value of money, in most cases not exceeding 6 per cent.

In the case of lands operated by the fee owners, the value as of Mch. 1, 1913, should properly be calculated as the present value of the profits, year by year, to exhaustion; unfortunately it is impracticable to determine such a value, as the profits are a widely varying quantity dependent on market conditions, and impossible to forecast far into the future. We would suggest substituting for the profits the normal royalty rate of the district, as indicated by recent leases, and determining the present value on the same basis as royalty coal. In this case the question of profits is minimized and it would seem that the discount rate might properly be taken at 6 per cent., leaving excess earnings to take care of the mining risk. As in the case of a sale, which would fix the depletion charge, the purchaser would expect to be able to earn more than 6 per cent. on any investment involving a mining hazard, and a 6 per cent. base on royalty value would probably fairly represent a fair sale value.

In determining the probable life of a property, consideration should be given to its past history as to output, its state of development, probable future output with normal conditions, and to the quantity of coal available on the property, or properly tributary to its development. As the present value of an annuity for 60 years is essentially equal to the present value of a perpetual annuity, it is probably wise to limit the present value of a property to the present value of the probable output for, say, 60 years, regardless of the total tonnage or life of the property. Acreage

that is not estimated to be mined within the 60-year period should be carried in an investment account not subject to depletion and, when opened, treated as new property. The present value of property with less than the maximum life just indicated should be based on its probable life, resulting, of course, in a higher depletion charge for short-lived properties.

Depreciation and Capital Charges.—No general policy in depreciation charges had been followed, the practice varying from charging everything to operation, to capitalizing all improvements and developments. In general, all plant and all opening and development charges, less the value of coal produced during this period, up to the time when the mine is opened and developed until able to produce its rated or intended capacity, should be charged to capital and be subject to depreciation; all charges for extensions, including plant and development work necessary to maintain capacity, should be charged to operating expense. In the case of new development or plant designed to increase capacity or materially reduce cost of operation, a new development account should be opened and the cost of providing such increased output should be charged to capital account.

The depreciation account should be so arranged as to extinguish the capital charge against any item of plant or development, when such item is either worn out or ceases to be useful to the operation, and it might be well to classify into groups the various divisions of capital charge, assigning to each group its probable average life and proper depletion charge. Repairs and renewal of parts should be charged to operation, but the life of plant should be figured considering such repairs and minor replacements. For instance, repairs and renewals in a breaker, either to machinery or structure, should be charged to operating expenses; but its extension or replacement by a new structure should be capitalized. Similarly, the retimbering of a shaft or main tunnel should be charged to operating cost, but its original cost should be depreciated so as to be wiped off the books on its abandonment.

Extraordinary Expense Account.—Large items of expense properly belonging in operating cost, but which would so affect monthly costs as to invalidate comparisons, may be put into an extraordinary expense account and this distributed annually into the operating expenses.

Insurance and Taxes.—Fire insurance and workmen's compensation should be pro rated with the monthly costs, as should local taxes. An insurance fund should also be maintained to provide against mining accidents, as fires, explosions, irruption of large bodies of water with resulting flooding, extensive squeezes, and similar accidents, which cannot properly be absorbed into operating expense.

Income and excess-profit taxes are chargeable against profits and are not proper items of operating expense.

Stripping Costs.—The cost of stripping overburden should be kept in a suspense account and charged against the coal as produced. This requires a reasonably accurate estimate of the coal to be produced by stripping, made from proper borings or, in the case of worked-over areas, from mine data. As such an estimate is an essential preliminary to any properly conducted stripping operation, there should be no difficulty in properly handling this account.

General.—It should be understood that the above accounting suggestions are the personal opinions of the author and have not been approved by any government department.

Conclusion.—The anthracite cost investigation supplements the bituminous price fixing previously described and, as it shows, probably for the first time, the actual range of anthracite costs, we believe that its inclusion in the *Transactions* of the Institute is warranted. The entire work is based on the costs reported to the Federal Trade Commission by the anthracite operators. The analysis and study was made by the Engineers Committee of the U. S. Fuel Administration, Messrs. Cyrus Garnsey, Jr., J. H. Allport, and the author, with the able assistance of Capt. R. H. Vorfelt, U. S. A., detailed temporarily to the Fuel Administration as Director of the Bureau of Investigation.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Standards for Brass and Bronze Foundries and Metal-finishing Processes*

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(New York Meeting, February, 1919)

WHILE brass and other copper alloys have long been listed as offering health hazards to their workers, it is questionable if the metals involved are alone responsible for the trades' records of morbidity. The entire science of foundry sanitation is the product of the past two decades; and the best standards now operative would have been regarded as little short of revolutionary prior to 1910.

The special handicap to the conservation of the health of the brass founder's employees has been the fact that, unlike the iron founder, his business could be profitably carried on in almost any small and unsanitary quarters. As a result, writers on occupational disease have accepted brass chills or brass founders' ague as an inevitable feature of the trade; and respiratory disabilities, as well as phthisis and disturbances of the nervous system, are also included as prevalent among those employed.

While there can be no question as to the basic accuracy of past investigations, there is every reason to doubt the necessity for an undue percentage of ill health among brass molders and casters who are safeguarded by scientific ventilating standards and by improving personal habits of sobriety. There is, however, need for a campaign of education as to the most approved practices and equipment whereby the employer may safeguard the health of his workers, and thereby reduce his labor turnover and increase his productive efficiency.

Broadly speaking, copper, tin, and aluminum carry negligible health hazards. The toxic qualities of lead, however, are a menace; especially if scrap lead is recovered or bought for foundry processes. The rapid volatilization of zinc renders its fumes and flocculent condensation the chief problems in conserving the health of the brass worker. The frequent presence in the foundry air of traces of arsenic compounds, lead

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oxides, carbon monoxide, oil fumes, and occasional mineral acid and alkali vapors, from cleansing and dipping processes, emphasizes the need for free natural or mechanical ventilation.

On the storage and transportation of the metals needed in furnace processes depends, to a minor extent, the amount of dust in the air. Where scrap lead is used, the poisonous dust accumulating in bins, or scattered during transportation, constitutes a hazard.

The use of stick phosphorus, instead of a phosphor-copper or phosphor-tin, as a scavenger in bronze is now practised in the small foundry only for economic reasons. Special instruction and warning as to its highly poisonous character and combustion-hazards are necessary in the case of new employees.

Foundry Construction

In foundry construction light and ventilation are the prime requisites. The English requirement of 2500 cu. ft. of air per brass worker engaged in sand foundry casting and of 3500 cu. ft. per worker in rolling-mill casting (or similar shops where continuous pouring is practised in foundries devoid of mechanical ventilation) is a reasonable standard for structural dimensions.

The mere provision of air space, however, is no guarantee of satisfactory productive and health standards. Adequate lighting calls for the provision of window and skylight area on a basis of 40 per cent. of the floor area, provided these are properly located and cleaned at least monthly. Fume and dust generally decrease the average of natural foundry illumination at the rate of 0.0625 to 0.25 per cent. daily. While the height of the side walls should be governed by the size of the foundry, a minimum of 15 ft. is essential for free natural ventilation.

Batteries of pivot center-hung windows satisfactorily meet the requirements of both ventilation and light. Illumination may be intensified by the substitution of wire glass for sections of the usual tight-construction roof of the monitor or side bays. Flat wire-glass skylights (hinged at the upper end to permit of their partial raising) will provide additional light and ventilation. The "hot-house" glass type of foundry construction, however, involves excessive sun exposure during 8 mo. of the year. Sawtooth roof construction gives admirable lighting but does not ensure satisfactory removal of fume and heat.

Since a southern exposure offers excess sunlight on the molding floor, it is well to install offices, core rooms, etc. on the south side of the building, leaving the west, north, and east walls free for lighting and ventilation of founding processes.

In sand-casting operations, the ingress of fresh air must be provided by windows; preferably pivot center-hung and operated in batteries. As too strong a draft of air may develop spills, during the cold months all

doors should be vestibuled except in the melting department and there also should be a convenient method of floor control over window openings.

In continuous pouring processes there should be a liberal provision of side doors, as well as horizontally or vertically pivoted windows. There should be an upward sweep of air from or near the level of the floor; no disadvantage to the product from chilling need be feared.

Roof Ventilation

While the new type of inverted center peak roof gives exceptionally satisfactory results, the monitor type is still universally accepted as the standard. The angle of the roof peak should not fall far below 30°, as the upward rush of fume is easily checked and deflected by flattening the apex. The width of a monitor should be at least 15 per cent. of that of the building and 20 per cent. is better as a wider monitor gives better lighting facilities. In a monitor having a greater width than 20 per cent. there is a probability of the chilling and backing of zinc fumes. The height of the side walls of the monitor should never fall below 4 ft. when open slat louvers run its entire length.

Pivot center-hung windows when installed, should run the length of the monitor and be at least 3 ft. in height, operated from the floor, and so swung through an arc of 90° that they may be kept in a horizontal position in clear weather, thereby creating a continuous draft through the monitor and preventing a downward current of chilled air.

Ordinarily, the monitor runs the full length of the building; but a type of cross-monitor construction, above cross batteries of pit furnaces and flasks, has been successful in preventing zinc fumes from being driven in the faces of casters to leeward of the prevailing air currents.

However satisfactory a liberal provision of the cowl or siphon type of natural-draft ventilator may have proved for general foundry conditions, the evolution of zinc fume in the pouring of yellow brass requires a freer roof ventilation than can be provided by any of the present models. This does not apply to individual installations over batteries of open-flame tilt furnaces, which are noted later.

Furnaces and Hoods

The pit crucible variety of furnace has long been the standard type for the brass and bronze industries. Open-flame oil and gas-fired furnaces, however, are now being used. The chief hygienic advantages of the pit crucible are: The initial melting fumes are almost invariably removed by the requisite chimney or stack draft; in tight-roof foundries mechanically ventilated hoods can be constructed above the batteries of fires, ensuring the safeguarding of the worker during incidental charging and skimming processes; the brass (usually yellow and carrying a high

percentage of zinc) is poured direct from the melting crucible, thus eliminating the double fume exposure called for in tilt furnace processes. The chief disadvantage of the pit furnace is the radiation of excessive heat. This may be overcome by a basement construction, which leaves at least a 6-ft. passageway (ventilated by flues or windows direct to the outer air) in front of the battery of fires. Ashes can be removed through this basement and the danger of a slow melt, from starved drafts dependent on working-floor conditions, is avoided.

Stacks

The question of adequate drafts for the pit furnace is governed by the diameter and height of the chimney and the number of fires it is designed to carry. Five fires or less call for a minimum stack diameter of 18 in.; thirty fires require a minimum diameter of 38 in.; and forty fires require a minimum of 45 in. Generally speaking, the height of the stack should be from twenty to twenty-five times the diameter; but adjacent buildings may make it necessary to increase these figures. The chilling of ascending heated currents of air by excessive height, however, is often responsible for the backing up of irritating and injurious fumes.

The chilling of ascending air currents is a greater handicap in the metal stack than the brick chimney. If preheating is necessary, it may be accomplished by introducing steam through a cock situated near the base or by burning wood to induce an up-draft before the actual fire is laid. The jacketing of an unlined metal stack by means of an outer shell, allowing about 2 in. of air space between it and the circumference, will prevent chilling and backing of fumes. A firebrick lining accomplishes the same result.

Hoods

In old-type foundries, the installation of a ventilated metal hood over the pit fires is a safeguard against incidental fumes and excessive heat. The area of the hood should equal the area occupied by the battery of fires and the pit and its lower edge should not be more than 6 ft. 3 in. above the floor level. Straight, natural-draft stacks direct to the outer air, not less than 24 in. in diameter, and in a proportion of one to every 10 ft. of hood length, may be preferably employed. If, for structural reasons, the ventilating stack leads to the main furnace stack, elbows should be avoided and the ventilating stack should enter the furnace stack at an angle of not more than 45°. Fans and a standard pipe system are requisite when free roof ventilation cannot be secured or the location of the main stack does not permit of satisfactory connection.

Where the battery of pit fires is located against an outer wall, center-hung windows, in a proportion of one to every five fires should be provided.

Since air currents always short-circuit along the lines of least resistance, free window ventilation or excess pull on a ventilating hood may hinder the pit-draft and a slow melt result. This may be prevented by the basement type of construction already noted; or by pit flues leading direct to the outer air. A pit 6 ft. deep by 7 ft. wide ensures freedom from the effects of short-circuiting.

Gratings

Grating bars should be set in the frame and not cast, thereby avoiding warping and accident hazards. Metal plates with staggered perforations may be used; but care must be taken against starving the pit draft by too scant provision of openings, unless special flues are provided. In continuous casting shops, the old-fashioned movable oak plank (in spite of accident risk) is frequently employed. The basement corridor construction permits a tight metal working floor, as the problem of excess heat is practically eliminated and all ashes are removed from below.

Gas and Oil-fed Furnaces

The open-flame oil furnace always requires hooding and direct stack ventilation to the outer air. When the roof construction prohibits natural draft, a deep hood and direct fan pull, unobstructed by elbows, is essential for the removal of fume and heat. The practical separation, by means of hooding or partial partition of the melting from the pouring process, is of unquestioned advantage.

On a 60-in. open-flame oil furnace, the angled, oblong bell of the hood should be at least 10 ft. long by 5 ft. 6 in. wide and installed at a height of not more than 6 ft. 6 in. above floor level. On a 42-in. furnace, the hood should be at least 6 ft. 6 in. long by 40 in. wide. When ordinary sheet iron is employed, the limited area upon which the direct flame impinges should be reinforced by an inner skin preferably of $\frac{3}{16}$-in. steel, which can be easily renewed, thereby conserving the life of the hood.

The single stack on the hood of a 42-in. open-flame oil furnace should be at least 30 in. in diameter; for the hood of a 60-in. open-flame oil furnace, the 36-in. stack is required. Where a double stack is installed over a 60-in. furnace, each stack should be at least 22 in. in diameter. A height, over all, of from six to eight times the diameter of the stack is sufficient, unless adjoining buildings make an increased height necessary. Since the danger points from brass fumes in skimming and initial pouring are located within the area protected by the hood, its size and ventilating capacity are of importance.

The same standards apply to tilt furnaces in the bronze foundry; where the less obvious hazard of arsenic fumes and products of combustion may prove a health menace.

Where a battery of Rockwell furnaces is located against an outer wall, a hood or metal curtain should be dropped from the roof over and in front of the line to within 6 ft. 6 in. of the working platform. Center-hung windows, in a proportion of one to each furnace, should be provided in addition to natural draft or revolving ventilating hoods direct to the outer air. If the wall can only be opened up near the eaves, wall fans may be installed. Where a dead wall exists but roof ventilation is possible, the hooded area should be provided with revolving ventilating hoods of an approved type, direct to the outer air. These should be in a proportion of one to every two furnaces and have a minimum diameter of 48 in. Where natural-draft stacks are employed, the same diameter is needed and a minimum height over all of six to eight times the diameter.

Where a battery of furnaces is located in or near the center of the workroom, a hood at least 10 ft. wide by 8 ft. high should be installed above the entire line, and dropped to within 6 ft. 6 in. of the floor. The ventilating provisions should be identical with those just described.

Ventilating System

For satisfactory mechanical ventilation of the tight-roof foundry, the cubic contents of the space from which air must be removed, as well as the frequency of change called for, should be scientifically computed. By installing a well-designed pipe system, with its branched openings dropped to within 3 ft. of the floor and connected to a housed fan, a steady change of air every few minutes can be maintained at a low expense of upkeep. Almost any of the numerous bladed types of exhaust fans may be used; but, generally speaking, the smaller the fan unit, the greater is the total horsepower expended for the given change of air.

In handling 6000 cu. ft. of air in a typical cellar foundry 20 by 30 by 10 ft., Table 1 may be taken as a guide. This table shows the relative

TABLE 1.—*Ventilation Data for Small Cellar Foundry*

Number of Exhaust Fan	Diameter of Exhauster Inlet, Inches	Horsepower Required	Cubic Feet of Air per Minute Delivered by Exhauster
3	17¼	2.48	4040
3½	20	3.85	5750
4	22¾	2.24	5740
4½	25¾	1.71	6130
5	28½	0.98	5870
5½	31½	0.65	5800
6	34¼	0.50	5970

costliness of upkeep, in horsepower expended, for a small fan installation. Even when driven at the higher speeds, the skin friction developed in too small a pipe makes the seeming initial economy an ultimate financial

handicap. A No. 3 fan handles but 4040 cu. ft. of air per min., with 2.48 horsepower, through a pipe having an area of approximately 1.5 sq. ft., and at a velocity of some 2666 ft. per min. A No. 6 fan easily handles 5970 cu. ft. per min., with less than ½ horsepower, through a pipe having an area of about 6.2 sq. ft., with a velocity of approximately 962 ft. per min.

Table 2 may be used to determine the size of the exhauster that will most economically provide the air change that healthful working conditions demand: In the case of a typical old-type foundry 20 by 30 by 10 ft. containing 6000 cu. ft. of air, a No. 3 exhaust fan using but 0.13 horsepower will give an approximately complete air change every 4 min. This 4-min. change is a safe minimum standard for a tight-roof foundry, provided local skimming-hood protection is provided in addition.

TABLE 2.—*Exhaust Fan Data*

Number of Exhaust Fan	Diameter of Exhauster Inlet, Inches	Horsepower Required	Cubic Feet of Air per Minute Delivered by Exhauster
3	17¼	0.13	1490
3½	20	0.17	2030
4	22¾	0.22	2650
4½	25¾	0.28	3360
5	28½	0.35	4150
5½	31½	0.42	5020
6	34¼	0.50	5970

The various fittings and accessories must conform to the standards of the New Jersey Bureau of Hygiene and Sanitation.

Local Skimming Hoods and Working Platforms

Yellow-brass foundries should install local exhaust hoods for the removal of skimming fumes; these are connected to the main exhaust system and are usually dropped beside the brick or iron supports of the bays. A 14-in. pipe flaring to a 24-in. hood at a point 3 ft. above the ground, the back of the hood being dropped to the floor level leaving a projecting half moon above the crucible, gives the best results. An air velocity of 3000 lin. ft. per min. should be maintained.

The bars of working platforms of stationary furnaces should be inset, not cast in the frame. No solid metal plates should be used, because of radiated heat.

Specifications for Exhaust Systems

The faulty construction of blower systems, due to lack of specific engineering standards, is the greatest handicap to satisfactory fume, heat,

and dust removal in the foundry. The questions of material and the scientific coördination of all details that will aid the flow of air generated, without increasing the cost of operation, must be fully understood to insure satisfactory results. Standard specifications are provided by the New Jersey Bureau of Hygiene and Sanitation.

Foundry Heating

The question of equalizing extremes of temperature by means of a mechanical heating and ventilating system is of prime importance to the employee and the employer in the larger sand-casting foundry. Few industrial health hazards are more depressing to vitality or more psychologically and physically conducive to intemperance than the damp chill of the unheated foundry. The prevalence of rheumatism and respiratory diseases among molders and casters is in some measure due to lack of dressing-room and washing facilities; but the prime cause for molders is the blanket of moisture-laden air above the damp molding floor of the one-shift plant, the temperature of which is not sufficiently raised to ensure evaporation until pouring takes place, and then only to a localized degree.

The best modern heating practice relies on a forced system of warm air diffusion by means of a housed fan and pipes. The fresh-air supply is drawn from the outside over a bank of steam coils, put through the fan, and then delivered through ducts to various points within a few feet of the floor level. By this means the coldest foundry may be heated in zero weather within from ½ hr. to 1 hr., the cold air in the foundry being rapidly displaced by the volume of heated outside air circulated by the fan. During preliminary heating the fan can be speeded to its maximum delivery; but as soon as a sufficient temperature has been reached, its normal speed can be resumed and maintained.

In addition to the advantage of placing the heated air at practically the floor level, this method permits thermostat control. By this means the amount of steam supplied through the heating coils can be automatically regulated; so that the temperature can be kept within 2° of the desired standard (55°) regardless of the outdoor temperature or the negligence or whims of any person. The necessity for guarding against the freezing of the molding sands dictates the maintenance of a safe minimum temperature at all hours during extreme weather.

Artificial Lighting

Foundry work is generally reckoned (in standard lighting codes) as requiring from 2 to 4 foot-candles. Whenever, owing to weather conditions or structural defects, natural light falls below this intensity,

artificial lighting must be used and may be roughly reckoned, with a good overhead system, on a basis that 1 foot-candle (spherical) per square foot of floor area will produce an illumination of about 3 foot-candles. A code of lighting has been prepared by the Bureau of Electrical Equipment, New Jersey Dept. of Labor.

The advantages of a good modern tungsten-lamp equipment in the foundry are: Increased production, greater accuracy in workmanship, reduced accident hazard, reduction of eye strain, reduction of labor turn-over due to more cheerful surroundings, lessening of fatigue and shop friction, promotion of good housekeeping, and improved facilities for superintendence and inspection. Owing to prevailing smoke and dust exposure, the lighting equipment deteriorates at the rate of 0.0625 to 0.25 per cent. daily. As in the case of windows and skylights, a regular follow-up system of cleaning should be maintained.

Floors and Gangways

The value of materials handled in the brass and bronze foundry does not permit a sand molding floor. Cement is more popular than brick with the workers, and metal-plate gangways are frequently adopted. Belgian brick makes a satisfactory molding floor. A layer of sand insulates the brick against incidental hazard from molten metal, and the sand can be easily collected and renewed when its periodical recovery-treatment for valuable content becomes necessary.

To avoid accident, it is essential to guard against excess moisture on all cement and metal-plate surfaces; and to set a minimum standard of 5 ft. for all main gangways along which the ladles must travel.

Flask Racks

Where small sized standard products are habitually handled, the use of rows of fixed metal racks, or horses, upon which the flasks may be laid before pouring, conserves the physical efficiency of the molder, by the resulting saving in foot-pounds of energy ordinarily expended in stooping to the flow-level.

Pattern Shop

All dust and refuse material produced by woodworking machinery in the pattern shop should be removed by an exhaust system, constructed in accordance with standard specifications, and provided with a device for injecting steam into the pipes to extinguish any blaze. Not only the conservation of health, but lessening of fire hazards dictate

such an installation. (See Standards of the New Jersey Bureau of Hygiene and Sanitation.)

Core Ovens

No type of oven, whether of the drawer or revolving-table variety, is always fume-tight during filling and discharging operations. Even though the oven is equipped with reasonably effective exhaust ventilation, a mechanically ventilated hood should be installed above the working doors. The hood should be of the same width as the core oven; and where only one set of doors or drawers is used, may be of the half-moon type overhanging the side where fumes are detected. A 5-in. ventilating pipe through which an air velocity of 1000 lin. ft. per min. is maintained is sufficient to care for every 5 ft. of oven width.

Where the core ovens are installed in a double-ended battery, worked on both sides, a hood should be suspended over the entire installation and mechanically ventilated by means of 5-in. pipes in the proportion of one to every 25 sq. ft. of hood. If natural-draft ventilation is relied upon, the ventilating pipe should run direct to the outer air, or enter an adiacent stack at an angle not to exceed 45°. The diameter of such a pipe should be at least 14 in. to every 25 sq. ft. of hood area.

Tumbling Barrels

All barrels should be equipped with exhaust pipes of the proper proportions. A minimum diameter of 4 in. is essential, and the suction generated may vary from 1 to 2 in. (static method) according to the character of the dust.

Buffing, Polishing, and Grinding

All dust generated in the process of buffing, polishing, and grinding should be removed by an exhaust system constructed in accordance with the details given in Table 3. A satisfactory balance must be maintained between the air exhausted and the supply admitted to take its place. Ingress openings should be at least three times the area of the egress openings. If evenly distributed, and if the air is admitted over warm steam coils in winter, a fairly draftless ventilating system can be maintained. Wheels of a special type may require larger pipe sizes than those indicated. (See Standards New Jersey Dept. of Labor). Steel safety hoods or some other approved safety device should be installed on solid grinding wheels.

All emery belts should be equipped with exhaust pipes, the size of which must be determined by the width and operation of the emery belts.

TABLE 3.—*Size of Branch Pipes for Buffing, Polishing, and Grinding Wheels*

Diameter of Wheels, Inches	Size of Branch Pipe for	
	Rag Wheels, Inches	Hard Wheels, Inches
6 or less	3.0	3
7 to 12	4.0	
7 to 16		4
13 to 16	4.5	
17 to 24	5.0	5
25 to 30	6.0	6

PROPORTIONS OF EXHAUST FAN AND PIPING

The inlet of the exhaust fan should be at least 20 per cent. greater in area than the combined areas of the several connections to the hoods, and this increase should be carried proportionately in the main pipe throughout the entire trunk line. The piping on the outlet of the exhauster should also be at least 20 per cent. greater in area than the combined areas of the several connections to the hoods. The main trunk line should be provided with suitable cleanouts not more than 10 ft. apart, and the end of the main trunk line should be blanked off with a removable cap placed on the end.

TEST

Sufficient suction head should be maintained in each branch pipe within 15 in. of the hood to displace 2 in. of water in a U-shaped tube. The pressure is to be taken by pressing the tube attachment over the small opening through the pipe, commonly called the static method. Tests are to be made with all branches open and unobstructed.

SAND-BLAST ROOMS AND APPARATUS

Sand-blast cabinets should be provided with reasonably dust-tight flaps or similar protective device over the two openings through which the workers' hands must be inserted and should be mechanically exhausted by means of at least a 3 or 3½-in. pipe connected to a fan system, through which a linear air velocity of at least 2000 ft. per min. is maintained. If a cover of fine wire gauze protects the back of the glass window through which the operative watches his work, the glass will not become clouded by the abrasive action of the sand. Working gauntlets should be provided and all parts of the cabinet kept in repair to guard against leaks.

On larger work and that which requires cleaning, the commercial

types of mechanically exhausted sand-blast barrels and rotary tables are both sanitary and satisfactory.

When the character of work handled is of too great a size to permit the employment of the rotary table, only the most approved make of air-tight and mechanically exhausted sand-blast room should be installed. It is essential that in addition to the overhead fresh-air supply, the floor be provided with a grating and be exhausted by means of a powerful down pull and that the operative be provided with special clothing and a helmet. In an efficient equipment the air of the room is completely changed every 6 sec.

Babbitt and Lead Alloys

As the lead content of white-metal bearing alloys may run as high as 90 per cent., the control of the health hazards involved in their production is serious. Scientifically speaking, there is no hazard from lead fume, as the temperature of the kettles is never allowed to run high enough to cause actual volatilization of the lead. The danger of lead poisoning is from the oxides that form on the surface of the molten metal, and are scattered as impalpable dust by every draft, or by the operation of charging and skimming.

When pig lead is habitually used, the health of the worker may be protected by means of a mechanically exhausted crescent-shaped hood installed at the back of the kettle. This open-shield hood covers from 33⅓ per cent. to 50 per cent. of the rear of the kettle, leaving the working side free. It is ventilated at its base by a pipe connected to a fan, and the minimum pull of 1000 lin. ft. per min. is sufficient to induce a steady air current away from the worker.

When scrap lead is used and when old bearings are melted out, etc., a tight exhaust hood is necessary; also extra cleanliness should be observed on the part of the workers. In all lead-kettle processes, metal receptacles should be used for skimmings and no lead materials should be allowed to accumulate on the working floors.

Dipping

No fumes caused by metal dipping in acid or alkali solutions should be permitted to contaminate the air of the workroom. They should be promptly removed at the point of origin by means of a boxlike duct installed at the back of the crocks commonly used. This duct should be constructed of wood or metal. The main duct should have a cross-sectional area at least equal to one-half the combined areas of exhaust openings. The bottom of main duct should be 7 in. wide; the front should incline at an angle of 115° to the bottom. Exhaust openings with an area equal to 25 per cent. of the area of the liquid giving off the fumes

should be located as near the point of origin of the fumes as the nature of the work will permit. A velocity of air of 1000 lin. ft. per min. should be generated in each exhaust opening. If sheet metal is used in the construction of the duct, an acid-resisting paint should be used to prevent corrosion. The exhaust fan should be treated with acid-resisting paint to prevent corrosion. Floor gratings should be provided and rubber gloves for the operatives.

Plating

It is essential that a system of mechanical ventilation ensure freedom from stagnant air in the plating room. This may be accomplished by means of wall fans, when the tanks are located near the side of the room; or by overhead hoods mechanically exhausted; or with ventilating stacks, when the plating operations are carried on in the middle of a department. A natural-draft hood, to be effective, should only depend on a stack or stacks direct to the outer air, in a proportion of a square 12-in. stack to every 36 sq. ft. of hood area. Wooden gratings should always be provided in the plating room and rubber gloves should be provided for the operators.

Enamels and Lacquers

The solvents for the pyroxylin, which forms the basis for the lacquers and enamels used on metal-finishing, are not only highly inflammable but poisonous to those exposed to their fumes. Wood alcohol, benzol, amylacetate, amylalcohol, volatile ketones, and acetone are (except the last two) admitted to be injurious to all who breathe them.

The fumes evolved during dipping or spraying should be controlled at their point of origin. Mechanically exhausted spray booths are now in the market, or may be "home made;" but the only type that should be chosen is one with an overhung top and a sufficient fan pull on the exhauster to ensure an air motion of at least 2000 lin. ft. per min. As the fumes are heavy, the exhaust vent should be at the back of the booth and on a level with the face of the operative. If a second exhaust opening is required on large work, a down pull through a bottom grating will be found more satisfactory than an overhead equipment.

A balanced supply of fresh air should be admitted to the lacquering department. This should pass over steam coils in winter, so as not to unduly lower the temperature of the room.

Washing, Toilet, and Dressing-room Facilities

Standards have been adopted for washing, toilet, and dressing-room facilities by the New Jersey Department of Labor.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Use of Manganese Alloys in Open-hearth Practice*

BY SAMUEL L. HOYT,† E. M., PH., MINNEAPOLIS, MINN.

(New York Meeting, February, 1919)

THE present report represents that part of the work that has been done by the War Minerals Investigation, Manganese Section, of the Bureau of Mines, on the use of manganese alloys in open-hearth practice. The magnitude of the work and the number of people participating in one way or another make it difficult to acknowledge adequately the services of all who have contributed to the success of the work. It would be amiss, however, to pass to the body of the report without mentioning the hearty coöperation and willingness to assist of the various manufacturing interests. With such a sympathetic attitude toward this investigation, our work was assured of success. Inasmuch as the unhappy circumstances that rendered this investigation necessary have now passed, this report is made in the hope that the results may prove of some permanent value to the peace-time operation of our open-hearth industry.

Broadly speaking, the purpose of the manganese investigation was to consider the most suitable means of utilizing our domestic supply of manganese and thus relieve, to the maximum extent possible, our shipping of the burden of importing manganese ores. It was not held that any decided shortage of manganese was imminent but rather that every legitimate means should be utilized for making our ship tonnage available to European service. While we have considerable metallic manganese in this country, it occurs largely as a low-grade mixture with iron or silica or with both. The open-hearth investigations, therefore, were carried on to determine the extent to which domestic or low-grade alloys could properly be substituted for high-grade alloys without materially impairing the steel production as to either quality or quantity. Also, it was held that such an investigation would yield valuable results to the steel industry as well as contribute, in no small way, toward

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directing future investigations in the same field. To the practical steel manufacturer, especially to him who felt no immediate concern about a manganese shortage, these last two points appeared to have a special significance. Another and quite obvious portion of the problem lay in the determination of the relative manganese conservation of the different practices, although any decided relief would more likely come from the other direction.

It was recognized at the start that considerable experience along our lines of attack had been gained at individual plants and that a compilation and digest of such results, supplemented possibly by our own investigations, would be the quickest method of approach. This, to a certain extent, controlled the selection of the actual steel plants at which it was desired to carry out the detailed investigations.

The evolution of the details of a definite experimental program from the statement of the general problem, considering the time element and the many and varied factors involved, was not lightly undertaken nor worked out without due consideration of competent metallurgical advice. After a preliminary survey, it seemed important to determine the conditions in open-hearth practice that would lead to a conservation of manganese, both during the working of the heat and in making the final additions; the most satisfactory metallurgical conditions for the use of manganese in the form of low-grade or special alloys; and the effect on the finished steel, as to both quality and "condition," of the various methods and processes studied. With these points in mind, steel plants were selected in which investigations bearing on one or more of these points could be carried out. To accomplish this, it was decided to determine slag and metal compositions during the refining of the heat and to observe the temperature each time a sample was taken, the latter to determine, if possible, the temperature effect. The recovery of manganese was to be determined from the residual and final manganese contents and the weight of the metal. To this end we took a sample of the finished steel, during teeming. By taking samples, at the beginning, toward the middle, and at the end of teeming, we were able to test for non-uniformity. This practice was generally observed throughout the investigation. The data secured were also supplemented by the plant records covering the heats in question as well as by our own observations made during refining, pouring, and teeming.

When planning the steps that should be taken to determine the quality and condition of the steel, it was found that no definite and well-proved method that could be adopted was available. True, the open-hearth melter knows whether his heat is in proper condition but we needed a quantitative estimate of "condition." Without attempting to enter upon a discussion of the physical chemistry of a heat of molten steel, we may say that the condition of a heat of steel must

depend, aside from the temperature, on the composition of the steel in those substances that affect the condition. Of these there are two kinds: (1) those that promote "openness," or the gases, which may be classified as gases that are products of bath reactions, which so far as we know are CO and possibly CO_2, and gases that are absorbed from the furnace gases, such as H, N, CO, and CO_2; and (2) substances that promote "soundness," such as the reducing and solidifying agents, C, Mn, Si, Al, etc. In general, it is held that Mn, Si, and Al inhibit the chemical reactions producing CO by reducing (or partly reducing) the principal constituent that produces the reaction, FeO.[1] The reduction of FeO is the principal means of "settling up" the liquid steel and it is for this reason that Mn is added in the finals. It is also held that Si and Al produce solidity in the finished steel, aside from reducing FeO and CO, either by keeping the hydrogen, nitrogen, etc., in solid solution or by preventing the dissociation of the compounds of those elements and iron.

The obvious procedure to get a quantitative estimate of the condition of the steel, considering both the behavior of the molten metal and the character of the ingot, would be to determine the amounts of the constituents in each of these two groups and to weigh one set against the other. Even this procedure would not, at present, lead to results which could be interpreted with entire confidence, even though there were no uncertainties in the analytic methods, inasmuch as we do not know the quantitative effect of each constituent either by itself or when associated with other constituents in varying amounts. In view of this uncertainty (lack of fundamental data), it was decided to make the analyses and use the results in a qualitative way, at least, to compare the different practices investigated.

Functions of Manganese

During such a critical period as that which has now passed, the question might be raised as to the possibility of eliminating manganese from steel making. This point was considered but it was at once held that the use of manganese is not merely an expedient, one for which some substitute might readily be made, but one of the basic requirements of successful, present-day, steel works' practice. It is quite true that in many cases the actual amount of manganese used in a heat of steel is greater than the purely metallurgical considerations would call for and any excess that might be used may well be considered as so much wasted.

The first function of manganese, broadly considered, is to refine and

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[1] In this statement only the metal bath is considered and it is held that FeO, and not Fe_2O_3, is in solution in the steel. According to this idea, reducing action on a slag containing Fe_2O_3 will produce FeO, part of which will enter the steel to react later with C, Mn, and other reducing agents present.

"settle up" the molten bath of steel. The aim is to put the metal in a proper condition for pouring and to produce ingots (or castings) of the desired quality and texture. While manganese is not the most efficient element that can be used for this purpose, calculated from the heat of combustion of the element to its oxide, it is the most satisfactory on account of the excellent condition (freedom from objectionable foreign inclusions) in which it leaves the bath. The theoretical amount of manganese required might possibly be calculated from the amount of oxygen converted from the active form FeO to the inactive form MnO. Assuming an oxygen content of 0.075 per cent. in the unsettled steel and of 0.015 per cent. in the finished steel (oxygen by the Ledebur method), the amount of manganese used in this way will be 0.2 per cent.[2] The amount of manganese required very naturally will vary with the condition of the bath and, in order to insure efficient "deoxidation," will be somewhat in excess of the calculated amount. A well-made heat of steel will probably not require more than 0.35 per cent. of manganese.

Manganese is also desirable in steel to improve the rolling properties, in which capacity it appears to serve a dual purpose. First, the manganese deoxidizes and refines the molten steel in such a way as to give ingots of the desired texture without robbing the steel of its hot-working properties. Such ingots may be rolled into finished shape without the formation, in excessive amount, of fissures or of surface defects. Other reducing agents, such as aluminum, silicon, etc., are prone to leave the metal in a poor condition for rolling and forging; while they eliminate one cause of hot shortness, iron oxide, they fail to convert the sulfur into a harmless form, as does manganese, and leave behind their highly refractory oxides, both of which tend to produce poor rolling qualities. Second, manganese, by retarding the rate of coalescence, or grain growth, renders steel less sensitive to the effects of the high rolling temperatures and is supposed to promote plasticity, at least in ordinary steels, at rolling temperatures. Silicon and aluminum, on the other hand, increase, rather than decrease, the grain size of steel. The amount of manganese required in this capacity probably does not exceed 0.35 per cent. in well-made steel. Finally, manganese is desired in the finished steel to secure certain physical or mechanical properties or to make the steel more amenable to subsequent heat treatment.

[2] The writer is informed by the Bureau of Standards that such a calculation is premature, due to our lack of knowledge on the subject of deoxidation and the faultiness of the Ledebur determinations. However, it would seem to the writer, from the work done at the Bureau of Standards ("A Critical Study of the Ledebur Method for Determining Oxygen in Iron and Steel" by J. R. Cain and Earl Pettijohn) that the amount of oxygen determined is the amount present as FeO (active form) subject possibly to an error due to partial reduction of CO during the determination. At any rate, the above is advanced as at least the first approximation of the amount of manganese required simply for destroying the ferrous oxide present in the bath.

Manganese is a very valuable element to the steel industry and its use cannot lightly be dispensed with. It is true that material, such as American Ingot Iron, can be successfully rolled even though no manganese is added, but greater time and care are required. Also, even though higher carbon steels with low manganese can be as successfully rolled, it would be impossible, in so far as we now know, to secure a satisfactory substitute for manganese, which is abundant in this country, to perform all three functions.[3]

Manganese conservation, viewed from this angle, will best be secured by eliminating the manganese specification except in case the amount of manganese present in the finished steel has some definite bearing on the properties or heat treatment of the steel. In other words, whenever only casting and rolling-mill practice (plant problems) are involved, the steel man should be allowed to exercise his own judgment as to the amount of manganese that should be used to give the most satisfactory and economical practice and the finish and quality of the product should be controlled by adequate inspection. On the basis of Mr. Ellicott's figures in *Iron Age* for June 6, 1918, by reducing the manganese requirements by 0.2 per cent. in making plates and shapes and other low-carbon steel (estimated tonnage 21,350,000), 54,000 tons of 80 per cent. ferromanganese could be saved.

Recommendations for Utilization of Domestic Alloys

As a result of this investigation, it is advanced that there are three practices for utilizing our domestic alloys in open-hearth practice that commend themselves; they are as follows, but not in the order of their importance.

1. The use of a molten spiegel mixture for deoxidation and recarburization.
2. The practice of melting and refining the steel bath so as to secure a comparatively high residual manganese content, about 0.3 per cent. manganese.
3. The use of manganese alloys containing silicon.

In selecting plants for investigating these practices, two points were kept in mind. The plant should have either "ordinary" practice, for the sake of comparison, or else one of the three just mentioned and the product or kind of steel made should be representative of the larger tonnages, such as shell steel, plates, sections, etc.

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[3] It is interesting to note that manganese, coming in the periodic system between iron and the strengthening elements on one side and the hardening elements on the other, serves the dual capacity of strengthening and hardening steel, which is not done by any other element.

Molten Spiegel Mixture Practice

The practice has been adopted, at a few plants, of combining in one operation both recarburization and deoxidation by using a mixture of pig iron and spiegel, which has been premelted in a cupola. This molten spiegel mixture contains from 5 to 11 per cent. manganese, 4 per cent. carbon, and the desired amount of silicon, and is added to the ladle during the tapping time in such a way as to get a thorough and uniform mixture of the two streams.

The principal advantages, not considering questions of plant and operating economy, are: A low-grade or domestic alloy can be used in the preparation of the mixture. The deoxidation is accomplished by means of a dilute solution with a consequent increase (on theoretical grounds) of the efficiency of the deoxidizer; this point will receive further consideration later. The deoxidizer is added in the molten state, securing thereby the attendant advantages of this practice, which will be considered at greater length. The amount of the recarburizer is comparatively large and the capacity of the plant is materially (and economically) increased thereby;[4] this is an advantage if a large steel output is desired. Compared to the usual practice of adding carbon and manganese, there should be less likelihood of missing a heat.

This practice, at least at the plant visited and it is understood to be the same elsewhere, is limited to the manufacture of the high-carbon steels, or those running 0.30 per cent. carbon or above. To make steels with 0.20 per cent. carbon would require the working of the carbon to about 0.10 per cent. carbon and the molten addition would have to contain about 20 per cent. manganese (spiegel). The amount of the addition would be reduced from 13,000 lb. (5896 kg.) to about 4000 lb. (1814 kg.) which would mean that some of the advantages just enumerated would decrease in weight and with the increased loss of manganese would probably mean that the practice would no longer be commercially feasible. However, when the other alternative, that is, the use of ferromanganese, either solid or liquid, is considered, the practice of premelting spiegel in the cupola would seem to commend itself as worthy of consideration. In case of undue shortage of high-grade ferromanganese, there can be no doubt but that the practice would offer a ready solution of the problem of using domestic alloys in making steel for shapes, plates, etc. Against the increased cost of production, compared to cold ferromanganese practice, there would be the greater uniformity of the product and the more uniform practice.

[4] There is some doubt as to the propriety of including the fourth as an advantage of this particular practice. The use of pig iron as a recarburizer may be accomplished in other ways with the same economy and increase in plant capacity.

High Residual Manganese Practice

At certain plants the practice of preferential oxidation and elimination of carbon and phosphorus has been developed by means of which the residual manganese is kept at a comparatively high value—about 0.25 to 0.30 per cent., as compared to 0.10 per cent. manganese, for a final carbon content of 0.10 per cent. This is accomplished, broadly speaking, by rapidly removing the phosphorus and retaining it as stable calcium phosphate during the earlier and colder period of melting, by maintaining a high finishing temperature and working the charge with a high manganese content so that the slag contains about 8 per cent. manganese, and by increasing the lime content of the slag to about 47 per cent. as a minimum.

This practice possesses undoubted advantages but they are probably best appreciated by those who have developed the practice and have it in operation on a sound commercial basis. First of all, correctly applied, it leads to the production of high-grade and uniform steel, which means increased rolling-mill practice, fewer rejections, and a more ready market. This is largely due to the fact that the steel is made, where it should be made, in the furnace. A second advantage is derived from the high MnO and CaO contents of the slag; manganese finals can be added to the furnace with a recovery that compares favorably with that of ladle additions. A third advantage is that the same pig iron used for the charge, which contains appreciably more manganese than ordinary basic iron, can be used to recarburize and partly deoxidize the bath; the remainder of the manganese is added as ferromanganese. At a steel plant that operates in conjunction with a blast-furnace plant, a harmonious and economical cycle of plant operations is made possible. At the same time the open-hearth slag can be resmelted in the blast furnace for the recovery of the iron and manganese and the utilization of the lime.

This practice is largely dependent on the amount of phosphorus in the slag, for it would not be worth while to recover the manganese at the expense of unduly increasing the phosphorus content of the pig iron. In this country we are fortunate in having a large amount of quite low-phosphorus ore available. No definite figure can be given as to the maximum allowable phosphorus content of the pig iron, but it is the opinion of at least one steel man who followed this practice that 0.6 per cent. phosphorus would not be prohibitive.

Under the conditions that prevailed during the past year, this practice possessed the additional advantages that high-manganese pig iron could be secured by smelting domestic manganiferous iron ore and that the manganese alloy added to the furnace at the end of the heat could as well be spiegel as ferromanganese, assuming that the finished steel

contains above about 0.10 per cent. carbon. This would not be without its disadvantages, one in particular being that the carbon content of the bath would have to be worked to a lower figure than in present practice. On account of the high cost of spiegel and the greater time required, it is doubtful whether the steel plants will substitute spiegel for ferromanganese. Another point in connection with the possibility of utilizing domestic manganiferous iron ore is that low silica ore can be added to the slag as a source of manganese oxide.

The high manganese content of the charge is generally secured by using a high-manganese pig iron, that is 2 or 3 per cent. of manganese; but it may also be secured by adding manganese ore to the slag or manganese alloys to the bath or by a combination of these methods. This point would be determined by plant economy but it seems doubtful whether the practice would be worth while unless a high-manganese pig iron were available.[5] The loss of this manganese, by which is meant its oxidation and transference to the slag, is quite great. This loss may be kept at a minimum by increasing the basicity of the slag in CaO and FeO, which, combined with the MnO which also acts as a base, exert the desired effect on the manganese of the bath. As the working of the charge progressess, its temperature rises until finally, with the high CaO, and particularly MnO, content of the slag, the carbon is eliminated more rapidly than the manganese, with the result that the manganese can be held to about 0.3 per cent. at the end of the heat. Present data indicate, unfortunately, that no material decrease in the amount of manganese required and no material increase in the recovery of manganese in the additions may be expected, so that the advantages are derived not from a decreased consumption but from the form in which it can be added. Data for one such heat showed that a total of 3728 lb. (1690 kg.) of manganese were used in one form or other to produce 1217 lb. (552 kg.) of manganese in the finished steel; or in other words that 3.06 lb. (1.38 kg.) of manganese were used to produce 1 lb. of manganese in the finished steel. The manganese added in the recarburizer and ferromanganese amounted to 1068 lb. (484 kg.) of which, assuming the manganese loss to come from these two sources, 838 lb. (380 kg.) were recovered in the finished steel, a recovery of 78.4 per cent. In this heat the ferromanganese was added to the furnace. Another heat selected at random, but more representative of standard practice, used 2190 lb. (993 kg.) of manganese to produce 1200 lb. (544 kg.) of manganese in the finished steel, or 1.82 lb. (0.8 kg.) of manganese (as compared to 3.06 lb.) to produce 1 lb. of manganese in the finished steel.

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[5] The writer is informed by one blast-furnace superintendent that running the manganese up to 2 per cent. does not materially affect the production, so that lowering of pig-iron production would not be held as a disadvantage in this practice.

Open-hearth Investigations

Open-hearth investigations, in which standard practice will be compared to molten spiegel practice and high residual manganese practice, will be described later after more complete analytic results have been received.

Use of Manganese-silicon Alloys

The high silica content of most of our domestic manganese and manganiferous iron ores made it advisable to consider the possible use of manganese-silicon alloys in steel making, in both acid and basic practice. For the purposes of the present discussion, these alloys will be divided roughly into two classes, high-grade silico-manganese containing about 50 per cent. manganese and 25 per cent. silicon, and low-grade silico-spiegel with about 15 to 20 per cent. silicon and 30 to 35 per cent. manganese with 50 per cent. iron. The manganese-silicon ratio of the first alloy is about 2 and of the second alloy varies from 2⅓ to 1½. Both of these alloys contain very little carbon. The high-grade alloys would be made from the siliceous manganese ores of California and Montana, and the low-grade alloys from the siliceous manganiferous iron ores of Minnesota.

While there is nothing new about the practice of using manganese-silicon alloys in steel making,[6] it may be well to review some of the points connected therewith in the light of present requirements. Silicon is always an efficient reducing or settling up agent when in the customary small amounts, but it may or may not be desirable in the finished steel. On this account the possibility of using manganese-silicon alloys depends on the amount of silicon that can be tolerated in the finished steel in the ingot form. In certain grades of steel, particularly in steel that must be welded, silicon should be low or practically absent. In steel for sheets and plates, which must give a good finished surface, most efficient rolling-mill practice requires that the silicon be kept tolerably low, but it is believed that from 0.10 to 0.15 per cent. could be used provided the manganese were not too high. In forging steel, high-carbon steels, and castings, where the aim is to produce sound steel, more silicon can be used, or between 0.20 and 0.35 per cent. Of these three fields, the last is the one where manganese-silicon alloys will find their first application. In the second field, it seems quite probable that conditions (to be discussed later) will many times permit their use; but from the very nature of things manganese-silicon alloys cannot be used to make steels of the first group.

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[6] It is understood that "silico-manganese" has been used fairly extensively in Europe, and in this country it was used at certain plants as standard practice until the supply was cut off by the war.

Manganese-silicon Alloys in Acid Practice

It is with considerable diffidence and hesitation that the discussion of manganese-silicon alloys in open-hearth practice is approached, particularly as the controversial character of many of the points is so clearly recognized. So it may be well, at the outset, to state briefly the manner in which the writer became interested in the possibilities of their use. A number of years ago, he was conducting a series of experiments on the occurrence and identification of foreign inclusions in acid open-hearth steel, principally ordnance steel. In this work ferromanganese, ferrosilicon, and a mixture of ferromanganese and ferrosilicon were added to a steel sample taken shortly after "oreing," that is to "wild" steel, in an attempt to produce an excess of the constituent, or constituents, that were supposed to form as a result of the addition. It seemed fairly clear as a result of this work that the use of silicon was apt to be dangerous, not on account of any harmful effect of the residual metallic silicon but because it produced a constituent (assumed to be SiO_2 or at least a highly refractory silicate) that was very likely to remain in the ingot and produce hot shortness. This suggested the idea that a manganese-silicon alloy might, and probably would, form a manganese silicate containing some ferrous oxide (a true slag) that would be fluid and more readily coalesce into larger particles than SiO_2, and, therefore, would free itself more readily from the steel. By using such an alloy, it would be possible to take full advantage of the use of silicon as a deoxidizer without suffering its usual attendant disadvantages. None of the manganese-silicon alloy was available at the time, so a parallel experiment could not be conducted.

Aside from the possibility of securing a better separation of the insoluble products of the deoxidation process, it was assumed as likely, from the fact that binary alloys are known to be generally more active, or powerful, than the weighted sum of the two constituents would indicate, that the alloy of manganese and silicon would prove to be a more powerful reducing agent than ferromanganese and ferrosilicon used separately. On reflection the thought occurs that manganese and silicon, reacting separately with FeO, would produce the oxides MnO or SiO_2, which may or may not form a solution of MnO and FeO or a silicate of iron. Manganese and silicon reacting as an alloy with FeO would produce a silicate of manganese, which may or may not form a double silicate with FeO. In either case we would expect to find the advantage in favor of the manganese-silicon alloy. The relative weight of the silico-manganese and the ferromanganese plus ferrosilicon mixture will be considered elsewhere.

Another point of great technical importance is the percentage recovery of manganese when added as silico-manganese and as ferromanganese

along with ferrosilicon. First of all let it be stated that a 100 per cent. recovery, based on the present theory of deoxidation, is hardly possible; and if possible would not be desirable. It would mean a retention of the products of the deoxidation, to be determined later as metallic manganese and silicon. A method of addition that would lead to a satisfactory deoxidation and yet would eliminate the loss due to admixture with the slag, volatilization, etc. and could be accomplished with the minimum amount of manganese, would be very desirable because it would lead to both conservation of manganese and uniformity of composition of the steel. The first of these points would be given by the actual value of the percentage recovery of the manganese and the second by the constancy of the percentage recovery.

Fortunately, the writer was able to examine records of heats made with silico-manganese covering a period of several years, from which some fairly satisfactory conclusions may be drawn bearing on these points. During this time when silico-manganese was being used there were periods when the alloy was not available and the ferromanganese plus ferrosilicon mixture had to be substituted. This afforded a direct comparison of these two methods of deoxidation. Certain results taken from the heat records, and which are believed to be typical,[7] are given in Table 1. Approximately, the silico-manganese contained

TABLE 1.—*Silico-manganese vs. Ferromanganese + Ferrosilicon*

Heat	FeSi, Pounds	FeMn, Pounds	SiMn, Pounds	Total Charge, Pounds	C, Per Cent.	Mn, Per Cent.	Si, Per Cent.	Mn Added, Pounds	Mn Recovered, Pounds	Per Cent. Recovery
A	160	300	...	31,160	0.26	0.56	0.294	240	174	72.5
B	215	400	...	40,765	0.21	0.57	0.306	320	232	72.5
C	160	310	...	30,620	0.32	0.63	0.312	248	193	77.8
D	160	300	...	30,910	0.27	0.70	0.318	240	216	90.0
E	215	400	...	40,865	0.24	0.72	0.312	320	294	91.8
F	...	40	470	41,010	0.22	0.58	0.308	281	238	84.7
G	...	35	350	30,685	0.26	0.60	0.302	214	184	86.0
H	...	40	470	40,960	0.21	0.64	0.310	281	261	93.0
I	...	40	470	40,510	0.21	0.66	0.308	281	267	95.0
J	...	40	420	36,760	0.24	0.68	0.310	255	250	98.0

53 per cent. manganese and 20 per cent. silicon; the ferromanganese, 80 per cent. manganese; and the ferrosilicon, 50 per cent. silicon. The residual manganese was neglected in calculating recoveries.

[7] It is obvious that the variation in heat composition and average manganese recovery of several years' practice cannot be given by this table. The records show greater uniformity for the silico-manganese heats.

It can hardly be claimed for these figures, or for the 3 years' records they represent with reasonable accuracy, that they furnish a truly scientific basis of comparison of the two alternate practices, but they do show that the same results (manganese and silicon contents of the finished steel), by using silico-manganese, can be obtained with consistently smaller amounts of both manganese and silicon, as compared to the combination of ferromanganese and ferrosilicon. In addition there is the advantage of having a more uniform practice, which in itself would warrant smaller additions. The weights of the additions favor the silico-manganese; thus in heats A and D, 460 lb. (208 kg.) and in heat C 470 lb. (213 kg.) were added as compared to 385 lb. (174 kg.) for G; and in B and E, 615 lb. (278 kg.) were added as compared to 510 lb. (231 kg.) in F, H, and I. The low carbon content of the silico-manganese may or may not be a material advantage but it is in favor of the single alloy addition because the carbon need not be worked as low and there seems to be less danger of missing the carbon.

Manganese-silicon Alloys in Electric-furnace Practice

No information is available, to the writer, bearing on the use of these alloys in electric-furnace practice, but we may at least consider such a possibility on the basis of their known behavior. Considering acid casting practice first, there seems to be no reasonable doubt but that either silico-manganese or silico-spiegel could be at once substituted for ferromanganese and ferrosilicon. Inasmuch as the usual aim is to make high-grade castings, the manganese-silicon alloys would appear to have the distinct advantage of making sounder and cleaner steel. Silico-spiegel, aside from possessing the theoretical advantage of being diluted with iron,[8] could be more readily prepared with the correct manganese-silicon ratio so as to eliminate the use of an additional alloy. The uncertainty of our knowledge as to the relative behavior of the manganese-silicon alloys as compared to the ferroalloys, and the relative efficiency of low-grade and high-grade alloys, as well as the importance of this step in the manufacture of steel, suggest the advisability of conducting a definite research to settle the points. It would seem that there is no better place for such a research than in this particular industry.

In basic electric-furnace practice the manganese-silicon alloys, on the same grounds, could likewise be utilized, particularly as the attempt is always to produce sound and clean ingots. However, in this practice, ferrosilicon is used as a reducing agent along with coke and hence the

[8] In this practice the advantage of greater dilution need not carry with it the disadvantage of increased weight on account of the higher temperature of the electric furnace.

operator would probably not see any advantage in changing his practice in favor of the manganese-silicon alloys.

Manganese-silicon Alloys in Basic Open-hearth Practice

The amount of information available on the use of silico-manganese in basic open-hearth practice is very meager, but it can be said that silico-manganese would probably be as satisfactory as ferromanganese and ferrosilicon. Through the coöperation of one steel plant, we were able to follow two shell-steel heats made with silico-manganese, which was added to the ladle. The second of these heats is given here to show what was done. To 11,100 lb. (5034 kg.) of molten pig iron in the ladle were tapped 122,340 lb. (estimated) (55,492 kg.) of steel analyzing C, 0.09, P, 0.012, Mn, 0.15, S, 0.033, Si, 0.02. At the same time 1000 lb. (453 kg.) of silico-manganese (50 per cent. manganese), 300 lb. (136 kg.) of 70 per cent. ferromanganese, 12 lb. (5 kg.) of aluminum, and 50 lb. (22 kg.) of coal were added to the ladle. The heat was in excellent condition and the ingots had smooth even tops and displayed no superficial action or evolution of gas. The final analysis was C, 0.44, P, 0.028, Mn, 0.58, S, 0.041, and Si, 0.21. The recovery of manganese, assuming the entire loss to come from the alloy added, was 77.5 per cent.; the recovery of silicon was 65.1 per cent. Only 24 lb. (10 kg.) of carbon, or 5 per cent. of the total, was lost. In the first heat, which was thought to be more highly oxidized, the recovery of silicon was only 58 per cent., while the recovery of manganese was 73.4 per cent. This indicates that silicon protects manganese in oxidized heats.

It was our intention to follow two more heats made by catching the carbon coming down and by adding the silico-manganese to the furnace just before tapping, but this has not as yet been done.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Basic Refractories for the Open Hearth

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(New York Meeting, February, 1919)

Preparation and Use.—Magnesite is an important refractory in open-hearth, heating, and electric furnaces for steel-making and in many of those employed in the metallurgy of copper and lead. It is sold in the form of brick, finely ground "furnace magnesite" for brick-laying, and dead-burned grains for making and repairing furnace bottoms. The latter are a mixture of granules varying in size from pieces of about 5/8 in. (1.6 cm.) diameter to very fine but sandy particles. Dead-burned magnesite results from calcining the crude or lightly burned mineral at a temperature that will not merely drive off practically all the CO_2, but will also cause sintering of the particles. During this process the pieces shrink considerably and become hard, dense, and inert to atmospheric moisture and CO_2; under-burned material, on the other hand, will hydrate on exposure to the air. A small percentage of ferric oxide seems to be necessary for the production of a satisfactory sinter; from 4.5 to 8 per cent. in the dead-burned grains is considered the most desirable amount.

Dolomite has been little used for brick-making in the United States, but it is prepared for use in the granular condition calcined or "double-burned" and is the principal ingredient of several materials offered for sale under various trade names for refractory purposes. Dolomitic refractories are almost wholly confined to the open-hearth and electric furnaces, where they are used for fettling and as substitutes for magnesite.

Much more magnesite and dolomite are used for basic open-hearth steel-making than for all other refractory purposes. The hearth of the furnace is usually built up of magnesite brick and dead-burned grain magnesite so laid that the brick base is protected by a working bottom of the granular material. The latter is sintered into place in layers 1 to 2 in. (2.5 to 5 cm.) thick to a total depth of 12 to 18 in. (30 to 45 cm.) at the center of the furnace. After each heat, burned dolomite is thrown against the banks as high as it will stick, and all holes in the bottom are filled. At most plants such holes, at the end of each week, are also

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carefully filled with dead-burned grain magnesite. For temporary patching dolomite is generally used as it sets more quickly than magnesite and its first cost is less.

Prior to 1914, the world's supply of refractory magnesite came almost wholly from the crystalline deposits of Austria-Hungary. Its superiority lies in its high refractoriness and long range of vitrification, which enable it to frit together at high temperatures without fusion or excessive softening. These properties are imparted by a fairly high content of iron oxide, together with an extremely low percentage of harmful impurities. The dead-burned Austrian magnesite sold in the United States had the following range of analysis: MgO, 83.7 to 87.3 per cent.; CaO, 1.9 to 3.9 per cent.; SiO_2, 1.1 to 4.1 per cent.; Fe_2O_3 and Al_2O_3, 4.7 to 8.6 per cent. With the cessation of shipping from Austria, magnesite was imported from Greece and Canada, domestic deposits were developed, and as a temporary expedient dolomite was substituted for magnesite where practicable. The deposits of this country are now developed sufficiently so that an adequate supply is available and ample reserves are blocked out to last many years. Table 1 shows the great expansion of domestic production since 1914. All figures are reduced to a calcined basis, assuming 2 T. of crude magnesite equal to 1 T. of calcined.

TABLE 1.—*Total Magnesite Consumption of United States on a Calcined Basis*

	1913	1914	1915	1916	1917
Imported, net tons	173,719	128,494	51,458	46,941	19,093
Domestic, net tons	4,816	5,646	15,250	77,487	158,419
Total, tons	178,535	134,140	66,708	124,428	177,512

At the beginning of the war, the refractory manufacturers were crippled by a lack of calcining facilities, since the Austrian material had been imported in the calcined condition. The low iron content of the available magnesite caused additional difficulties. In order to confer the proper sintering and bonding properties, it became necessary to add iron oxide and to incorporate it thoroughly by burning at an extremely high temperature. Magnesite thus treated, if sufficiently low in harmful impurities, is a high-grade refractory and has given conspicuously satisfactory service.

Grecian Deposits.—These deposits are of the amorphous type and had been operated on a large scale for many years but their output was rapidly increased after the war began. Considerable magnesite was imported from Greece in 1915 and 1916, but shipments were suspended late in the latter year. Much of it is of exceptional purity, as shown by

the following typical analyses of crude rock; though some of the imported material was very high in CaO and SiO_2, due doubtless to improper selection at the mines. The percentage of impurities after calcination will be practically double these figures on account of the loss of CO_2.

Analyses of Crude Magnesite from Greece

SiO_2	0.67	0.46	1.19	1.63	2.28
Al_2O_3 and Fe_2O_3	0.30	0.50	0.43	1.36	0.19
CaO	0.92	1.24	0.80	1.44	1.56
MgO	46.06	46.22	45.83	45.75	44.78
Ignition loss	52.16	51.51	50.42	49.88	49.76
	100.11	99.93	98.67	100.06	98.57

Magnesite of Grenville District, Quebec.—This magnesite is white to grayish, finely crystalline, and high in lime due to dolomitic inclusions. Wilson,[1] in 1917, estimated that there were in sight a little under 700,000 T. in the deposits of the district containing less than 12 per cent. lime (equivalent to over 20 per cent. lime when burned). It has been stated that when calcined and mixed with furnace slag or dead-burned with iron ore, the Canadian magnesite has given satisfactory service in furnace bottoms.[2] However, the leading refractory manufacturers prefer the purer mineral of California and Washington, and endeavor to maintain the CaO content below 4 per cent. in the dead-burned material. During the period of greatest scarcity of magnesite, the Canadian product was utilized by several companies in the manufacture of magnesia brick as a minor constituent of the mix, but this practice has probably been entirely abandoned. It is, however, being employed for the production of dead-burned grain magnesite, by sintering with iron oxide in rotary kilns.

California Magnesite.—This magnesite, which is of the amorphous type, is found at many places. It occurs in the form of veins, lenses, and stockwork in serpentine; the deposits are usually small. The largest and most important are those near Porterville, Tulare Co., and St. Helena, Napa Co. Prior to 1914, about 10,000 T. were being produced annually, hence the mines had not become sufficiently developed or equipped to produce large tonnages before the summer of 1916. Transportation was a serious problem in the rainy seasons, as nearly all of the deposits are a number of miles from the railroad and hauling to the cars is done by means of trucks. Variations in quality at first caused the users considerable difficulty. It was often hard to keep the silica and lime contents within the proper limits, due to the impurity of some deposits and the

[1] M. E. Wilson: Magnesite Deposits of Grenville District, Quebec. Canad. Dept. of Mines *Memoir* 98 (1917) 52.

[2] A. Stansfield: *Iron and Coal Tr. Rev.* (Jan. 12, 1917) **94**, 31.

lack of uniformity in the tenor of others, as well as to the common inexperience of the operators. Most of these difficulties were gradually lessened and in 1917 the production had risen to 211,663 net tons of crude magnesite.[3] In the meantime, a considerable number of calcining plants had been erected near the mines, in order to give the rock a light burning before shipment. Since a loss in weight of about 50 per cent. occurs in this burning, a material saving in freight resulted. Recently the California production has fallen off, due to the competition of the larger and less expensively operated deposits of Washington. The first

Typical Analyses of Californian Crude Magnesite

SiO_2	3.25	5.18	1.10	3.86	1.55
Fe_2O_3 and Al_2O_3	2.20	1.10	0.40	0.80	0.45
CaO	1.25	3.34	Trace	2.04	1.38
MgO	43.87	41.92	46.54	43.47	45.68
CO_2	49.53	48.78	51.20	49.48	50.97
	100.10	100.32	99.24	99.65	100.03

analysis, which is uncommonly high in iron for magnesite of this type, is representative of a unique deposit near St. Helena, Napa Co.

Magnesite Deposits of Washington.—These deposits have become a most important factor in the market since their discovery in 1916; 715 tons of crude rock were mined and shipped in the latter part of that year, and 105,175 tons were produced in 1917. The mineral is finely to coarsely crystalline and shows many variations in color from white to gray, pink, red, and black. Mining is done by both open-quarry and underground methods. It is reported that diamond drilling at the Finch Quarry of the Northwest Magnesite Co. has proved the existence of more than 1,000,000 T., and that on more than one of the properties an estimate of 1,000,000 T. within 200 ft. of the surface is reasonable.[4] Prior to the erection of calcining plants at the properties many thousand tons of crude rock had been shipped in which the silica content was uniformly below 3.5 per cent. and lime less than 1.5 per cent. The analyses given below are typical.

Typical Analyses of Washington Magnesite

SiO_2	1.9	3.3	4.3	0.6
Fe_2O_3 and Al_2O_3	1.0	1.0	0.8	1.2
CaO	1.7	1.4	1.1	0.5
MgO	45.2	44.8	45.0	46.4
Co_2	49.7	49.3	49.5	51.0
	99.5	99.8	100.7	99.7

[3] C. G. Yale and R. W. Stone: Magnesite in 1917. *Mineral Resources of the United States*, 1917 (1918), Pt. 2, 65.

Yale and Stone: *Op. cit.*

Calcination is now being done near the quarries, and dead-burned magnesite for refractory use to which iron oxide is added during manufacture is being produced in rotary kilns. The material as marketed by one producer has the following average analysis: MgO, 82.5 per cent.; CaO, 3.4 per cent.; SiO_2, 6.5 per cent.; Fe_2O_3 and Al_2O_3, 7.25 per cent.; loss on ignition, 0.5 per cent.

Dolomitic Refractories.—Prior to the war few basic bottoms had been built of dolomite, which was little used except for temporary patching and the fettling between heats. Since 1914, however, calcined dolomite and specially prepared dolomitic materials have been common substitutes for magnesite, being placed in the furnace in the same manner as the grain magnesite. Within recent months the tendency on the part of steel makers has been to displace burned dolomite by specially prepared dolomites for the temporary patching and to return to the use of high-grade magnesite for all original installations and major repairs.

In the calcination of dolomite either vertical or rotary kilns may be used. In the latter case the rock is usually crushed to pass approximately a ⅝-in. (16-mm.) screen, the fine powder screened out, and the granules burned. For best results the heat applied must be sufficiently intense not merely to drive off the CO_2, but to cause the pieces to shrink and become hard and dense. The rock is frequently "double-burned" by being heated in one kiln merely high enough to drive off most of the CO_2, and further shrunk in a second at a higher temperature. The usual range of composition of the crude rock is CaO, 28 to 35 per cent.; MgO, 14 to 20 per cent.; SiO_2, 1 to 7 per cent.; Al_2O_3, 0 to 4 per cent.; Fe_2O_3, 0.5 to 5 per cent.; CO_2, 43 to 46 per cent. As high a magnesia content as possible is considered desirable.

Burned dolomite as ordinarily prepared air-slakes readily on account of the high percentage of lime. For that reason it cannot be kept in stock for any length of time without deterioration and should be made just before use. In a furnace having a dolomite bottom the gas is preferably kept on even during shutdowns, otherwise a new bottom may be required on starting up again. With good magnesite this never occurs. Since dolomite does not set as solidly as magnesite, patches are more apt to become detached and float in the bath.

Special Dolomitic Refractories.—Within the last few years, numerous investigations have been undertaken in the attempt to overcome the marked slaking properties and other defects of calcined dolomite. As a result several articles consisting of specially prepared dolomite have been placed on the market under various trade names, some of which are superior to ordinary calcined dolomite, being more resistant to atmospheric slaking and giving better service in the furnace. In most of these preparations the granules are coated or impregnated with pul-

verized basic slag, iron ore, or similar material by burning at a high temperature in a rotary kiln. The attempt has likewise been made to coat the crushed rock with a pulverized slag suspension in water, so that upon burning a protective coating will be formed on the surface.[5] In other cases the slaking properties are diminished by using an impure dolomite, preferably one high in iron. The analysis considered most desirable may be obtained by mixing raw rock of different compositions.

One patented material is prepared by grinding together dolomite and iron ore to form an intimate mixture and calcining at a temperature reported to exceed 2850° F. (1565° C.). The finished product for furnace bottoms is said to show the following range of analysis: CaO, 42 to 55 per cent.; MgO, 38 to 25 per cent.; SiO_2, 6 to 13 per cent.; Fe_2O_3 and Al_2O_3, 8 to 14 per cent.

Another compound consists of an intimate mixture of granular dolomite and about 10 per cent. basic open-hearth slag. The manufacturers prefer hard, compact and dense varieties of dolomite, as high as possible in magnesia. It is said that the granules, after calcination in a rotary kiln at about 2800° F. (1540° C.), are mixed, upon coming from the kiln and while still hot, with the granulated slag and the mixture is sent through a rotary cooler. It is claimed by the manufacturers that material thus prepared may be transported without slaking when the magnesia content is high and the dolomite is extremely hard burned. The average analyses of several shipments is given herewith: CaO, 48 to 55 per cent.; MgO, 29 to 32 per cent.; SiO_2, 4 to 11.5 per cent.; Al_2O_3, 3 to 6.5 per cent.; Fe_2O_3, 4 to 7 per cent.

Laboratory Tests

The relative value of different materials used in the open-hearth furnace is measured by the service obtained and by that alone. Neither theoretical considerations nor the results of laboratory tests can be expected to demonstrate precisely what these relative values may be, although much can be learned from such studies. With these facts in mind, the authors some months ago planned a brief series of tests designed to compare properties of various basic materials that evidently affect the durability of these materials in the furnace. The results of these experiments, which were carried out under the direction of Raymond M. Howe at the Mellon Institute of Industrial Research of the University of Pittsburgh, are described here.

The wearing away of the basic bottom is due to the abrasive action of the slag and metal frothing during the process of oxidation, the scour-

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[5] A. V. Bleininger: Some Aspects of the Testing of Refractories. *Proc.* Eng. Soc. Westn. Pa. (1916–1917) **32**, 612.

ing out of holes caused by boiling when the heat becomes excessive, chemical reactions between constituents of the hearth and of the bath or slag, and possibly a few other minor causes. It is not to be expected that furnace conditions can be reproduced in laboratory tests; these can merely be so arranged as to show the relative resistance of different materials to destructive forces logically assumed to be similar to certain of those in the furnace.

It is well known that all basic refractories soften at high temperatures and it is believed that the softer the bottom the more rapidly will the scouring action take place. Other things being equal, the material that shows the least degree of softening at operating temperatures should give the longest service. Tests were therefore made to determine this property.

Corrosion of the lining due to chemical action is harmful, not only because of the wearing away of the refractory but because the surface of the hearth becomes weakened and less resistant to abrasion. It has been suggested that the impurity in the melt most likely to have a strongly corrosive action upon the lining is phosphorus and that the reason magnesite bottoms last longer than dolomite bottoms is due largely to the superior resistance of magnesite to the oxides of phosphorus, which have a strong affinity for lime. An investigation regarding the relative resistance of various basic refractory products to the action of a corrosive melt high in phosphorus is included in the tests here described.

The ignition loss of basic refractories should be as low as possible, since a high ignition loss results in excessive wastage in the furnace. The rate at which different materials absorb moisture and CO_2 has been studied in this connection.

Basic Materials Studied.—The six materials studied include two magnesites, two dolomites, and two specially treated dolomites. Throughout the remainder of the paper these will be designated by the letters *A*, *B*, *C*, *D*, *E*, and *F*. The material designated as *A* was prepared from Washington magnesite, ground with ferric oxide, and dead burned.

Table 2.—*Analyses of Basic Materials*

	A	B	C	D	E	F
Moisture and ignition loss per cent	0.43	0.33	0.47	1.00	3.70	9.90
Silica, per cent	7.36	4.56	11.46	9.84	6.68	2.16
Alumina, per cent	2.33	2.08	3.91	1.86	3.89	0.90
Ferric oxide, per cent	4.81	7.88	4.41	4.54	1.69	1.10
Lime, per cent	3.12	18.94	47.92	48.70	49.84	51.00
Magnesia, per cent	81.60	66.40	32.10	34.73	34.50	34.85
Total	99.63	100.19	100.27	100.67	100.30	99.91

TABLE 3.—*Recalculated Analyses of Basic Materials*

	A	B	C	D	E	F
Silica, per cent	7.40	4.57	11.52	9.94	6.93	2.40
Alumina, per cent	2.34	2.08	3.93	1.88	4.03	1.00
Ferric oxide, per cent	4.83	7.89	4.43	4.58	1.73	1.22
Lime, per cent	3.13	18.96	48.15	49.19	51.64	56.61
Magnesia, per cent	81.93	66.66	32.26	35.18	35.75	38.69
Total	99.63	100.16	100.29	100.77	100.08	99.92

B is a similar product prepared from Canadian magnesite. *C* is a preparation made by coating dolomite granules at a high temperature with basic open-hearth slag. *D* is made by mixing together iron oxide and dolomite and calcining at a high temperature. *E* is a relatively impure dolomite that has been calcined. *F* is a rather pure calcined dolomite. The analyses of these materials at the time of arrival are given in Table 2 and these analyses recalculated on a zero ignition loss basis to make them more comparable in Table 3.

Slaking Tests.—From the very manner in which basic materials are prepared, it can be assumed that a low ignition loss and the least possible tendency to slake are essential properties. Buyers of refractory products do not wish to pay for something that is lost as soon as the material is heated. For example, the 10 per cent. ignition loss of *F* will cause the loss of considerable money were such material to be used on an extensive scale. It has been said that these materials "powder" more or less when they give off CO_2 or water during heating. A part of this powder is carried out of the furnace by the draft, resulting in an additional loss in material, as well as injury to the checkers. It is suggested that the driving off of moisture and CO_2 under the action of the heat may also interfere with proper setting of the granules to a dense mass and thereby decrease the resistance to erosion.

Two methods of procedure were followed in the slaking tests. In the first, the materials were allowed to stand exposed to the air and each month a sample was taken, dried at 110° C., and its ignition loss determined. The results of this series of tests are not yet available. The second procedure consisted of moistening the different materials from time to time with water. Samples were then taken at intervals of 5 days, dried at 110° C., and the loss on ignition determined. The results are given in Table 4. Table 5 represents the ignition loss of recalcined *E* and *F*; it was deemed necessary to recalcine these two products because of their high loss at the beginning of the test.

TABLE 4.—*Percentage Loss on Ignition at Regular Intervals*

	A	*B*	*C*	*D*	*E*	*F*
Loss at beginning of slaking test......	0.02	0.20	0.08	0.95	3.93	14.04
Loss after 5 days..................	0.48	0.69	1.20	5.67	18.45	25.52
Loss after 10 days..................	0.95	1.52	1.62	8.35	20.00	26.30
Loss after 15 days..................	1.24	1.94	2.39	10.10	23.30	33.00
Loss after 20 days..................	1.36	1.92	3.01	10.92	23.66	29.70
Loss after 25 days..................	2.09	2.65	6.30	12.00	24.33	25.99
Loss after 30 days..................	2.54	3.25	4.63	14.99	24.67	30.81

TABLE 5.—*Percentage of Loss Upon Ignition of Recalcined E and F*

	E	*F*		*E*	*F*
Loss after recalcination.	1.55	1.29			
Loss after 1 day.......	5.16	9.74	Loss after 10 days....	15.80	
Loss after 2 days......	9.40		Loss after 12 days.....		23.53
Loss after 3 days......	12.79	15.81	Loss after 15 days.....	17.09	
Loss after 5 days......	12.81	16.43	Loss after 25 days	17.36	

The results given in these Tables are also plotted graphically in Fig. 1. Table 6 gives the analytical and slaking data.

TABLE 6.—*Analytical and Slaking Data*

Material	*A*	*B*	*C*	*D*	*E*	*F*
Order of resistance to slaking....	1st	2d	3d	4th	5th	6th
Lime, per cent.................	3.16	18.96	48.15	49.19	51.64	56.61
Magnesia, per cent.............	81.72	66.66	32.26	35.18	35.75	38.69
Silica, alumina, and ferric oxide, per cent.....................	14.70	14.54	19.88	16.40	12.69	4.62

It is to be observed that in the case of both magnesites and dolomites the slaking tendency increases directly with the lime content and that in the case of the dolomites it varies inversely with the sums of the iron oxide, silica, and alumina contents. The state of these impurities, whether they are natural or artificial, undoubtedly exerts an influence that these tests do not reveal. In the latter case the thoroughness with which the granules are coated or impregnated with ore or slag is an important factor. The magnesite low in lime, *A*, showed a greater resistance to slaking than the one high in lime, *B*. The low-slaking tendency of *C* apparently proves that the granules were well protected by the slag coating. It is somewhat higher in impurities and lower in lime than *D*, a treated dolomite that slaked badly. *E* was the more stable of the two

calcined dolomites; its condition at the time of receipt was far superior to that of *F*. It is believed that these two cases serve as the best examples of the effect of lime content and fluxes upon the rate of slaking. The air-slaking series, although incomplete, indicates that the different materials stand in the same relative order as given above.

A study of the figures given indicates that the lime content should be as low as possible and that iron oxide, alumina, and silica, within limits dependent on the character of the dolomite and its treatment, are necessary

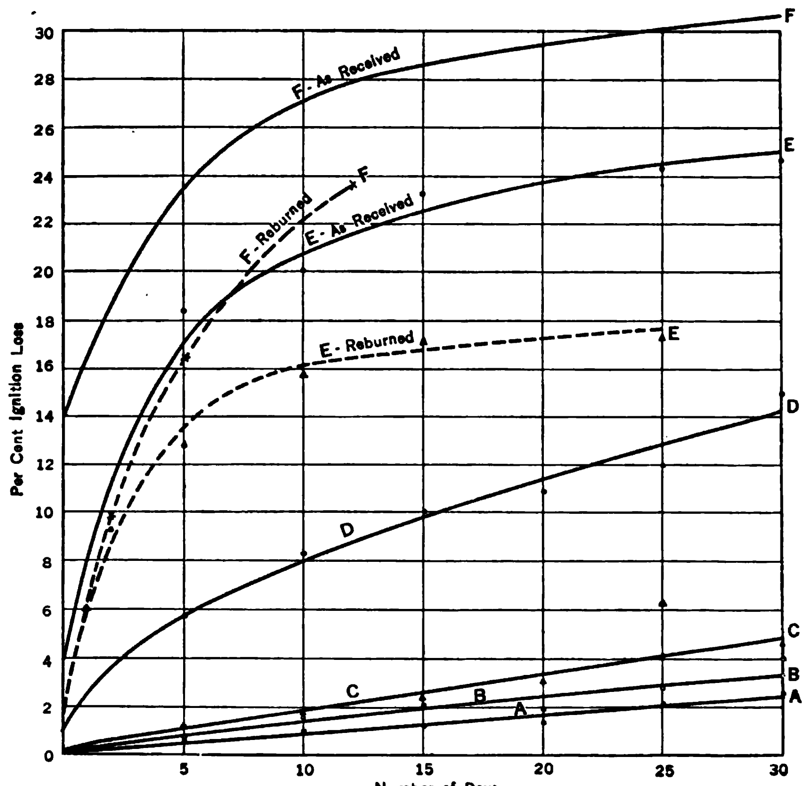

Fig. 1.—Increase of loss on ignition of basic materials under the influence of moisture.

in dolomitic refractories, if the slaking is to be kept within practicable limits; further, that a dead-burned magnesite free from lime, and possibly containing a fairly high percentage of impurities (10 to 15 per cent. of SiO_2, Al_2O_3, and Fe_2O_3) is the most suitable basic refractory for withstanding the conditions of this test. These conditions represent the influences to which basic materials may often be subjected in cars or when stored in the plant. Pure calcined limestone is the poorest material to withstand such conditions. Other combinations of the lime-magnesia

series will arrange themselves in intermediate positions according to the lime, alumina, silica, and ferric-oxide content, and the temperature of burning.

Action Between Basic Materials and Fireclay or Silica Brick.—Failure is liable to result because of chemical reactions when basic materials are in contact with fireclay or silica brick at high temperatures. The latter are not uncommonly used in contact with magnesia brick above the slag line of the open hearth, but this is not considered the best practice and a buffer layer of chrome brick is desirable. With this exception the basic materials are generally carefully separated from silica and clay brick in furnace practice. In view of these facts the following tests were made to show the relative limits of safety when the materials mentioned are heated in contact. Moreover, it was believed that the behavior of the basic products in this test would afford an indication of their relative chemical activity and a measure of their probable resistance to corrosion in the furnace.

Cones sawed from bricks and placed in pats of basic materials were treated in a pot furnace together with a fireclay pat containing standard Orton pyrometric cones. Specimen *A* was found, after a few trials, to react with firebrick between Orton cones 18 and 26. A pat was then heated rapidly to cone 18 and although this temperature was held for 3 hr. no action was observed. Another pat at cone 19 showed the same result. A third pat heated to cone 20 and held for 3 hr. resulted in a violent reaction between the magnesite and firebrick. This procedure was followed in each case.

TABLE 7.—*Reacting Temperatures in Orton Cones between Basic Materials and Brick*

Material	Fire Brick	Silica Brick	Lime Content of Basic Material, Per Cent.
A..............................	Cone 20	Cone 26+	3.16
B..............................	Cone 18	Cone 18+	18.96
C..............................	Cone 15	Cone 16	49.19
D..............................	Cone 15	Cone 16	48.15

The figures given in Table 7 illustrate the tendency of lime to lower the reacting temperature and to increase the chemical activity of the basic refractories. It is probable that the temperatures shown are much too high for practical limits of safety, and that they are only relatively true.

The firebrick formed a thin liquid and ran into the magnesite; the shadows in Fig. 2 show where the firebrick had been. The silica brick cones behaved differently and can be seen as they were at the end of

the test, having cut away the magnesite without the formation of a visible slag.

Crucible Tests.—Basic refractories, besides withstanding slaking and erosion, must resist considerable chemical action. Carbon, phosphorus, and silicon are present in the metal bath in the form of carbides, phosphides, silicides, or in an oxidized condition. The oxides of phosphorus are known to have a marked affinity for lime, for which reason basic materials high in lime should be expected to give less service in the furnace hearth than materials low in this oxide, notwithstanding the additions of lime made to slag the phosphorus. The lining is necessarily exposed, at least locally, to the corrosive influence of phosphorus in the melt until it is removed. A series of crucible tests was, therefore, conducted for the purpose of studying the action of phosphorus compounds on the six basic materials.

The general plan was to make crucibles of the different products, heat them to a certain temperature, introduce a corrosive mixture, allow it to react for equal lengths of time upon the different crucibles, cool, and analyze the melted portion for silica, lime, and magnesia. Since these three oxides could come only from the crucible their presence in the melt would prove chemical action.

Crucible series 1 involved the use of crucibles 3.5 in. (8.8 cm.) in diameter and 2.5 in. (6.2 cm.) in height, made from the materials as received and bonded by means of gum tragacanth. It was impossible to make crucibles of the above type from material *F* so the basic materials were packed in fireclay crucibles 3 in. (7.6 cm.) in diameter and 4 in. (10 cm.) in height in series II, III, and IV. In each case the corrosive mixture added consisted of one part ferrophosphide and two parts ferric oxide, which was used to oxidize the phosphide and was itself reduced in the process. The mixture was added to the hot crucibles by means of an iron ladle. At the conclusion of the melting period the crucibles were cooled, sawed vertically through the center, and samples taken from the melt for analysis.

In the first series of tests the crucibles were heated to 1350° C., 100 gm. of the corrosive mixture was added and allowed to react at this temperature 2 hr. The crucibles are shown in Fig. 3. In the second series, the crucibles were heated to 1300° C. when 100 gm. of corrosive mixture was allowed to react upon them for ½ hr.; the action at the end of this time was too slight to be determined. In the third series of tests, the crucibles were heated to 1300° C. and 100 gm. of corrosive mixture was allowed to react at this temperature for ½ hr.; then the temperature of the furnace was increased to 1350° C., 50 more gm. of mixture was added, and the temperature held constant for ½ hr. The extent of the corrosive action is shown by Fig. 4. The fourth series of tests was con-

FIG. 2.—PATS SHOWING ACTION OF MAGNESITE UPON FIREBRICK AND SILICA BRICK. I. ORTON CONES IN CLAY PAT. II. SILICA BRICK CONES IN MAGNESITE PAT. III. FIREBRICK CONES IN MAGNESITE PAT.

FIG. 3.—CRUCIBLES USED IN CRUCIBLE SERIES I.

FIG. 4.—CRUCIBLES USED IN CRUCIBLE SERIES III.

ducted by heating the crucibles to 1300° C. and adding 100 gm. of corrosive mixture; after ½ hr. the furnace temperature was raised to 1350° and 50 gm. more introduced; ½ hr. later an additional 50 gm. of mixture was added and the temperature maintained ½ hr. longer. Partial analyses of the slags resulting from these tests are given in Table 8.

The analyses of the slags from crucibles *C*, *D*, and *F* in the fourth series should not be compared with those of the same crucibles given in the preceding series, since under the more severe conditions of this test additional reactions came into play. The Fe_3P-Fe_2O_3 mixture had eaten through the bottoms of crucibles *C*, *D*, and *F* as shown in Fig. 5 and a series of reactions resulted between the corrosive mixture, the basic material, and the clay of the crucible, with the formation of a very active fluid

FIG. 5.—CRUCIBLES USED IN CRUCIBLE SERIES IV.

slag. The silica, lime, and magnesia contents of this slag were influenced by the action of the clay as well as by that of the phosphorus.

TABLE 8.—*Partial Results of Crucible Tests*

Material	Analyses of Slags from First Series				Analyses of Slags from Third Series				Analyses of Slags from Fourth Series				Order of Resistance to Corrosion
	Silica	Lime	Magnesia	Total	Silica	Lime	Magnesia	Total	Silica	Lime	Magnesia	Total	
A	0.00	0.12	1.30	1.42	0.21	0.08	0.35	0.64	0.32	0.04	1.23	1.59	First
B	0.31	0.10	1.33	1.74	0.34	0.22	1.55	2.11	0.74	0.46	3.52	4.72	Second
C	0.64	0.81	0.69	2.14	2.24	1.42	1.58	5.24	6.20	7.48	4.18	17.86	Fourth
D	0.64	1.48	1.47	3.59	9.98	4.55	6.86	21.39	18.90	22.14	14.90	55.94	Sixth
E	0.51	0.83	0.64	1.98	1.82	1.13	1.58	4.53	1.56	1.44	1.53	4.53	Third
F					1.72	5.37	5.42	12.51	24.52	12.70	8.12	45.34	Fifth

These tests show that the relative corrosion of the various basic materials places the low-lime magnesite first in resistance to the action of the corrosive mixture, the high-lime magnesite second, a calcined dolomite third, a treated dolomite fourth, another calcined dolomite and a treated dolomite fifth and sixth respectively. The materials lowest in lime offered the most resistance to the action of this corrosive mixture. The superiority of the low-lime magnesite, the intermediate position of the

high-lime magnesite, and the general lower resistance of the dolomites establish this conclusively. Other oxides as well as lime were taken into the solution but the intensity of this action seems to have been dependent on the amount of lime present. Only limited conclusions can be drawn from these results. Other factors being the same, it should be expected that the basic refractories lowest in lime should give the best service where exposed to the corrosive action of melts containing phosphorus, such as those of the basic open-hearth furnace. However, the relative value of the materials studied can merely be approximated.

Analysis of the slags from the specially treated dolomites gave unexpected results. Material *C* showed slightly less resistance to corrosion than the calcined impure dolomite *E*; at the same time material *D*, another specially treated product, was decidedly inferior to *E* and *F*, both dolomites that had been calcined without any effort to coat or protect the granules by special methods. To what extent the special treatment accorded the patented dolomitic products is an advantage in increasing the resistance to corrosion is open to question.

Tests Upon Dead-burned Magnesite and Magnesite Brick

The preceding tests have served to distinguish between magnesites and dolomites. The latter part of the work applies to magnesites only, and the tests were made somewhat more severe in order to secure more pronounced results.

Crucible Tests on Magnesites.—Crucibles made of magnesite grains were subjected to tests similar to those described but under more severe conditions. Crucibles like those employed in the first series were used

Table 9.—*Partial Analyses of Slags From Crucible Tests*

Material	*A*	*B*
Silica	2.56	2.96
Lime	0.40	2.28
Magnesia	2.46	6.38
Total	5.42	11.62

and 600 gm. of the corrosive mixture added hourly in 150-gm. batches. A temperature of 1350° C. was maintained for 4 hr. The marked superiority of magnesite *A*, in resistance to corrosion, was shown in the preceding experiments and is developed even more strikingly in this one.

Load Tests.—It seems probable that unsatisfactory service would be caused by any marked softening of the bottoms, for the boiling of the bath will have a greater tendency to scour out holes in a hearth that is soft than in one that is more rigid. In order to study the rigidity of magnesites *A* and *B* at high temperatures, bricks having the compositions

given were made from each by the usual brick-making methods, and subjected to a load test. These brick were heated under a load of 25 lb. per sq. in. (1.7 kg. per sq. cm.), applied on the end of the brick with a temperature increase of 250° C. per hr., until failure resulted. Brick *A* failed by shearing at 1555° C., evidently due to a breaking of the bond; brick *B*

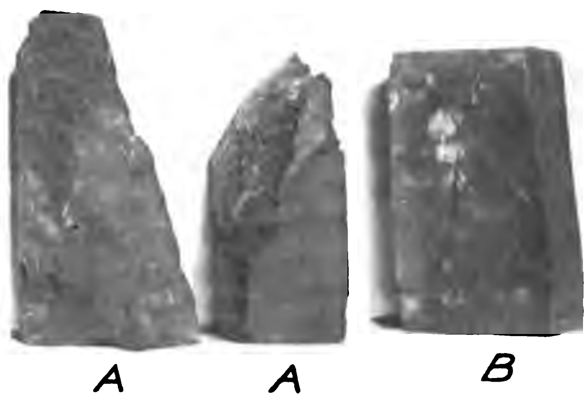

Fig. 6.—*A*. Typical failure of Brick *A* in load test. *B*. Failure of Brick *B* in load test. Original dimensions 8.75 in. by 4.13 in. by 2.53 in.; final dimensions, 7.66 in. by 4.31 in. by 2.72 in.

did not shear but softened and settled at high temperatures. By the time 1450° C. had been reached, it had shortened 12.5 per cent. of its original length, see Fig. 6.

Table 10.—*Analyses of Magnesite Bricks Tested*

Material	*A*	*B*
Ignition loss	0.26	0.37
Silica	7.26	5.72
Alumina	2.14	2.00
Ferric oxide	4.95	5.94
Lime	3.18	15.05
Magnesia	82.40	70.84
Total	100.19	99.92

Since magnesite *A* shows no evidence of softening at the temperature of the test while magnesite *B* shows considerable, it is to be expected that the former should show a much greater resistance to the erosion of boiling metal than the latter.

Fusion Tests.—The difference in softening temperatures of the two magnesites indicated that fusion-point data might be of value. It was hoped that the fusion points of the magnesites and also of intimate mixtures of finely ground slag and magnesite might be obtained. Were

the latter possible, comparative values could be established. One could state, for example, that a mixture of 80 per cent. of magnesite *X* and 20 per cent. of slag was equivalent to a mixture of 60 per cent. of magnesite *Y* and 40 per cent. of slag. Cones were accordingly made up, some of 100 per cent. magnesite and others of magnesite mixed with from 10 to 90 per cent. of basic open-hearth slag. In the endeavor to compare the fusion points of these mixtures with those of Orton cones numerous difficulties were encountered.

It was first necessary to devise a method for placing the test pieces in material that would be neutral to both cones and magnesite. After several failures, successful cone pats were made in the following manner. One half of the pat was made of fireclay and Orton cones were placed in this; the other half, in which the test cones were placed, was made of magnesite. The two half pats were joined to form a disk 3 in. in diameter and finely ground chrome ore used at the junction to separate the magnesite and fireclay. The disk was then placed upon a fireclay pedestal that had been sprinkled with crushed chrome ore. This combination was necessary to prevent the magnesite from attacking the high-temperature Orton cones, or the fireclay of the pat.

When the method for conducting the tests had been devised, it was found that the slag ran from the cones at high temperatures and left a magnesite shell standing. The results of such tests were therefore disappointing. Slightly better but inconclusive results were obtained when ferric oxide was used in place of the slag. Cones of 100 per cent. magnesite also gave poor results, because of the tendency of this material to volatilize at high temperatures.

Bar Tests.—In discussing fusions, it was suggested that a test that would determine the relative values of different basic materials when mixed with varying amounts of slag would be of value. The load test indicated differences in the softening points of magnesites *A* and *B* but the attempted study of fusion points revealed nothing. It was hoped, therefore, that a series of bar tests, conducted in the following manner, would combine information that might have been secured from the other two.

Magnesite and basic open-hearth slag were ground to pass 60-mesh, weighed out in the proportions indicated, and mixed with gum tragacanth. The mixtures were molded into bars 1 in. $\times$ 3/8 in. $\times$ 6 in. (2.5 $\times$ 0.9 $\times$ 15 cm.), which, when dry, were strong enough to be introduced into the furnace. They were laid flat on silica brick and heated to 1250° C., a temperature sufficient to produce a certain amount of sintering. The sintered bars were placed in a test furnace and supported between bricks placed 4½ in. (12 cm.) apart, being separated from the latter by chrome ore powder. The furnace was then heated at the rate of 100° C. temperature increase per hour, and the softening points were observed. The observations are given in Tables 11 and 12.

TABLE 11.—*Bar-test Data with Magnesite A*

Mixture	Furnace Temperature at which Softening Began, in Degrees C.	Remarks
100% *A*	Samples broke	Too refractory to become bonded by this treatment.
70% *A* + 30% slag	1370	Action complete (sagging of 2 in.) in about 2 min.
60% *A* + 40% slag	1350	
50% *A* + 50% slag	1350	
40% *A* + 60% slag	1350	
30% *A* + 70% slag	1345	
25% *A* + 75% slag	1340	
20% *A* + 80% slag	1330	
15% *A* + 85% slag	1320	
10% *A* + 90% slag	1310	

FIG. 7.—TYPICAL BAR TEST RESULTS.

These mixtures showed no evidence of softening until the temperature of failure had been reached. In the entire series sagging began at a point above the fusion point of the slag, which melts at 1290° to 1300° C.

TABLE 12.—*Bar-test Data with Magnesite B*

Mixture	Furnace Temperature at which Softening and Sagging Began, in Degrees C.	Remarks
100% *B*	1285	These bars sagged about 1 in. in 1 hr. when 1350° C. had been reached.
95% *B* + 5% slag	1280	
90% *B* + 10% slag	1260	Had sagged 2 in. at 1340° C.
85% *B* + 15% slag	1275	Had sagged 2 in. at 1350° C.
80% *B* + 20% slag	1280	
70% *B* + 30% slag	1260	
60% *B* + 40% slag	1250	
50% *B* + 50% slag	1260	

All magnesite *B* bars, as shown in Table 12, began to soften about 1 hr. before the action was complete (when they had sagged 2 in.), and at about the melting point of the slag or a trifle lower. The temperatures at which the bars had sagged 2 in. were nearly the same when appreciable amounts of slag were present.

The results of the bar tests are not easy to interpret and it is not possible to state that the softening tendency of a slag-magnesite mixture of one series is equivalent to that of a definite mixture of the other. Failure of the bars evidently occurred through softening and fusion of the slag. The melting temperature of the latter seems to have been raised by admixture with magnesite *A*, and depressed by magnesite *B*. What the significance of the latter fact may be is not clear.

Summary

1. *Comparison of Low-lime and High-lime Magnesite.*—The magnesite that was the lower in lime showed less tendency to slake and higher refractoriness, as well as greater resistance to attack by firebrick and silica brick, and to the action of a corrosive Fe_3P-Fe_2O_3 mixture.

2. *Comparison of Dolomitic Materials.*—The materials highest in impurities and lowest in lime were most resistant to slaking. With one specially prepared dolomite *C* in which the granules had been coated with basic open-hearth slag, the inherent tendency of dolomite to slake had been overcome to a great extent. Another special preparation of similar character *D* showed practically the same degree of slaking as the untreated dolomites. The specially treated dolomite *C* withstood the action of the corrosive mixture not quite as well as an untreated dolomite high in impurities, and much better than the second special preparation *D*. Except material *D*, the purest dolomite showed the poorest resistance to corrosion, although this may perhaps be explained by the high ignition loss of the material as received and used.

3. *Comparison of Magnesite and Dolomite.*—The magnesites are more resistant than the dolomites or dolomitic preparations to slaking, also to the action of the corrosive Fe_3P-Fe_2O_3 mixture and that of fireclay and silica. One of the specially treated dolomites has a slaking tendency so low as to group it with the magnesites as far as this property is concerned. However, in resistance to corrosion it compares more closely with the untreated calcined dolomite high in impurities.

4. Considering these tests only, the value for refractory purposes of the materials studied may be placed in the following order: First, *A*, a magnesite low in lime; second, *B*, a magnesite high in lime; third, *C*, a treated dolomite; fourth, *D*, a calcined dolomite high in impurities; fifth, *E*, a treated dolomite; sixth, *F*, a pure calcined dolomite low in impurities.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Path of Rupture in Steel Fusion Welds*

BY S. W. MILLER,† ROCHESTER, N. Y.

(New York Meeting, February, 1919)

MOST of the steel welding done at the present time is in material containing not over 0.3 per cent. carbon, and the tests here described were in similar material. These tests are not as yet completed but it is hoped that more results and more reasons for the conclusions may be presented at the meeting in February.

From the time the author found the peculiar structure in electric welds referred to in a previous paper,[1] that is, needles or plates in the grains and similar material, in larger spots, at the grain boundaries, he has felt that these plates which may be iron nitride and probably contain some carbon, were at least partly responsible for the brittleness of electric welds. He has found but few traces of similar lines in oxyacetylene welds until the last 2 mo., when he has found them in large numbers under certain conditions. In the top of these welds, they are quite numerous. In the body of heavy oxyacetylene welds, they appear at times, but not nearly to the extent that they do in electric welds; the author has never seen them in the body of welds in material less than 3⁄4 in. (19 mm.) thick. They are shown in Fig. 82. The reason they were not noticed before is undoubtedly due to the fact that in making tests of welded pieces the weld was always ground off level with the plate, and as this structure only appears in the top 1⁄16 in. (1.5 mm.) of the weld, they were removed by the grinding or machining; also, welds 3⁄4 in. thick had not been examined.

It did not appear, in making bending tests, that this structure had much influence on the strength of oxyacetylene welds; while electric welds are noticeably brittle. Further, oxyacetylene welds made with certain special materials were exceedingly brittle even after the tops of the welds were removed; this was true in cases where there was no sign of the plates whatever and where the welds were remarkably free from oxide and the other usual defects. It appeared, therefore, that this brittleness did not depend on any variable that had been noticed so far, and it was

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* Report of Research under the joint auspices of National Research Council and Emergency Fleet Corporation.

† Proprietor, Rochester Welding Works.

[1] *Bull.* 134 (Feb., 1918) 391.

decided to find where the rupture occurred in various kinds of welds made with various materials, in order to determine, if possible, the cause of the brittleness that existed under such widely varying conditions.

A small testing machine was made, in which a specimen ⅜ in. (9.5 mm.) wide and up to ¼ in. (6.3 mm.) thick could be bent, after being polished and etched, and examined under the microscope. The results have been quite satisfactory, although unexpected, and the author hopes that further tests will make matters still more clear.

Table 1 gives the information regarding the pieces referred to by the photographs. The figures given for carbon, etc., are approximate only for no analysis has been made. All these pieces were tested by bending except EWQ, EWN, CBE1, and BS1. The work as planned includes further tests of other pieces and of pieces that are heat-treated in various ways. There are many difficulties in attempting to present, by means of photographs, results that are more easily seen under the microscope. Among them is the trouble of finding fields that can be photographed; also, most of the distortions are so out of focus that they cannot be photographed, although they can be readily seen with the eye. Again, it has been found that an exposure about four or five times as long as with surfaces that are etched in the usual way, and that are not distorted is

TABLE 1.—*Description of Test Pieces*

Mark	Original Material	Weld Material	Process	Thickness of Material Inch
CF2	Tank plate	Vanadium steel	Oxyacetylene	0.50
RA1	Tank plate	Roebling oxyacetylene welding wire	Oxyacetylene	0.50
RE2	Tank plate	Roebling electric welding wire	Oxyacetylene	0.50
106	Ship plate	0.25 per cent. carbon steel wire	Electric	0.50
40C	Tank plate	0.40 per cent. carbon steel wire	Oxyacetylene	0.50
4C4	Tank plate	0.40 per cent. carbon steel wire	Oxyacetylene	0.50
Q	Bar steel	Not known, covered electrode	Electric	0.25
A	Armco iron	Not welded		0.50
EWQ	Tank plate	Roebling electric welding wire	Electric	0.50
EWN	Tank plate	Roebling electric welding wire	Electric	0.50
CBE1	Tank plate	Roebling electric welding wire with 2 per per cent. aluminum	Carbon arc	0.50
BSI	Ship plate	Roebling oxyacetylene welding wire	Oxyacetylene	0.75

ARMCO IRON.

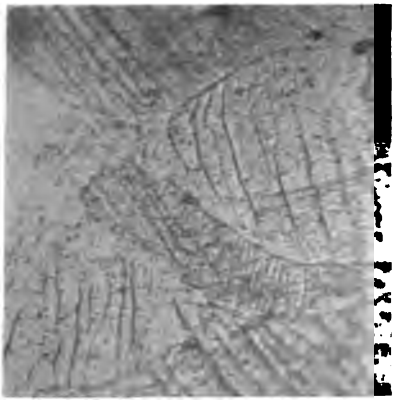
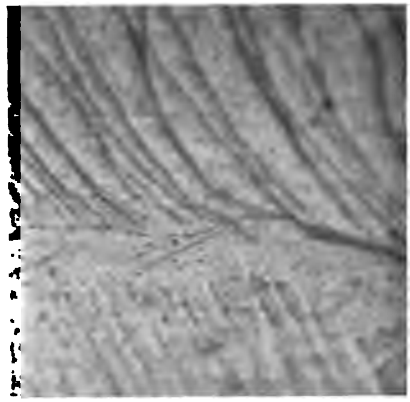



FIG. 1. FIG. 2.

FIG. 1.—AFTER STRAIN SLIP BANDS APPEAR IN NEARLY EVERY GRAIN. × 430.
FIG. 2.—SLIP BANDS CURVE TOWARD GRAIN BOUNDARIES. × 430.

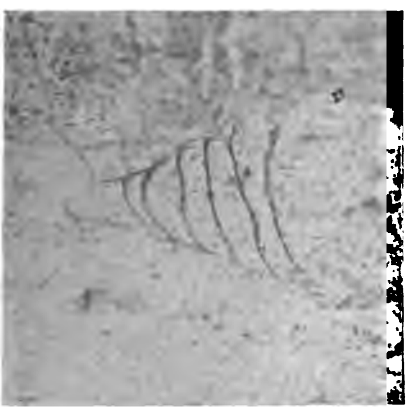
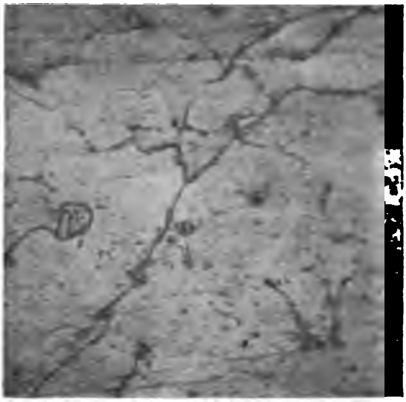



FIG. 3. FIG. 4.

FIG. 3.—ANOTHER SET OF CURVED SLIP BANDS. THIS IS VERY COMMON IN THIS MATERIAL. × 430.
FIG. 4.—SLIP BANDS INTEGRATING INTO GRAIN BOUNDARY RUPTURE. EDGES OF CRACK ROUNDED, NOT SHARP AS IN CF_2, 106, ETC. × 430.

In Armco iron the grain boundaries are stronger than the slip planes. Because of higher tensile strength of CF_2, 106, etc., their grain boundaries and slip planes are probably stronger than the slip planes of Armco iron, though they may be weaker than Armco iron grain boundaries.

SPEÇIMEN 40C.



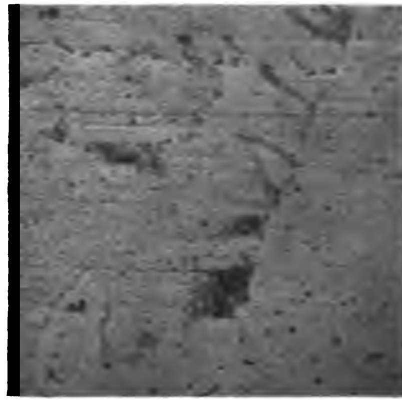


FIG. 5. FIG. 6.

FIG. 5.—USUAL STRUCTURE OF WELD. PEARLITE AND CEMENTITE AT GRAIN BOUNDARIES. × 430.

FIG. 6.—OXIDE FILMS AT GRAIN BOUNDARIES. THEY ARE OF THE ORDER OF 1/40,000 IN. THICK. MANY OF THEM IN THIS WELD. × 430.

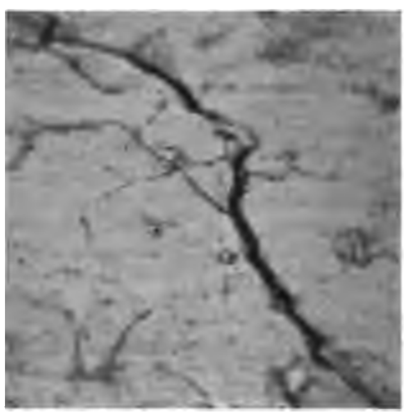


FIG. 7.—GRAIN BOUNDARY RUPTURE AT OXIDE FILMS OF FIG. 6. × 430.

Specimen 40C. was made by a welder who had never used this welding material; he did not float the dirt to the surface, and it went to the grain boundaries. His lack of experience also made the weld lower in carbon than it should be. Because of the many defects, test was stopped, but no slip bands had appeared.

SPECIMEN 106.

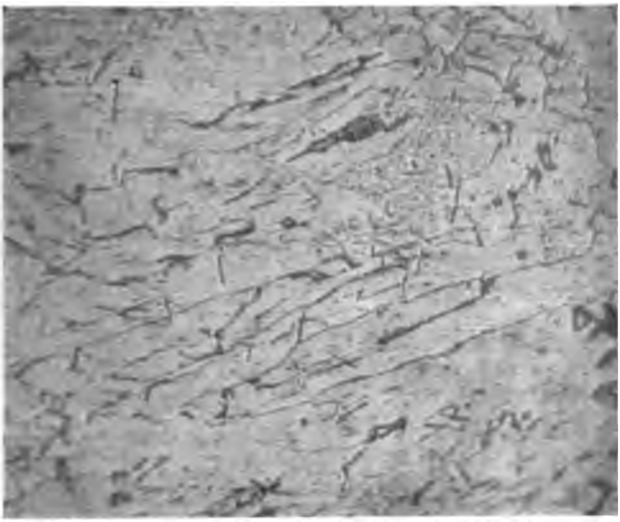


FIG. 8.—USUAL STRUCTURE OF COLUMNAR GRAINS, WITH LINES AND SPOTS AS USUAL IN ELECTRIC WELDS. × 430.

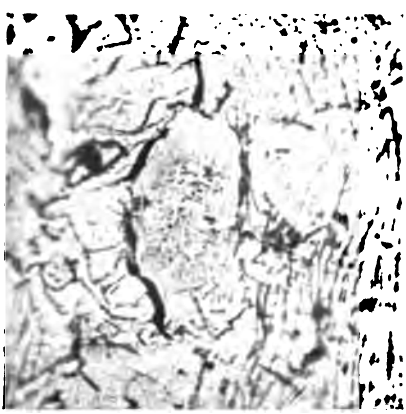


FIG. 9. FIG. 10.

FIG. 9.—INTERGRANULAR RUPTURE, POSSIBLY DUE TO OXIDE FILMS. × 430.
FIG. 10.—INTERGRANULAR RUPTURE, NOT DUE TO OXIDE FILMS. × 430.

SPECIMEN 106.

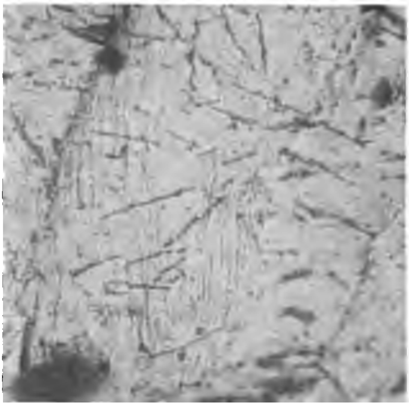


FIG. 11.

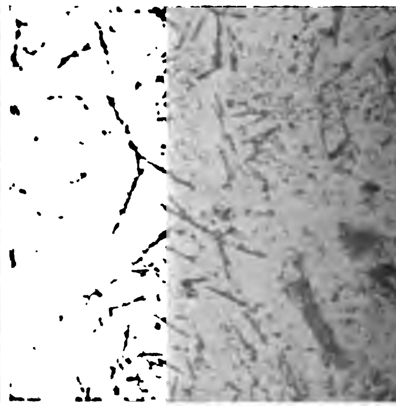


FIG. 12.

FIG. 11.—SLIP BANDS; THEY ARE INDEPENDENT OF THE DIRECTIONS OF THE LINES AND IN MOST CASES CROSS THEM. × 430.

FIG. 12.—SLIP BANDS AT 45° TO DIRECTION OF STRAIN; AGAIN THEY CROSS THE PLATES. × 430.

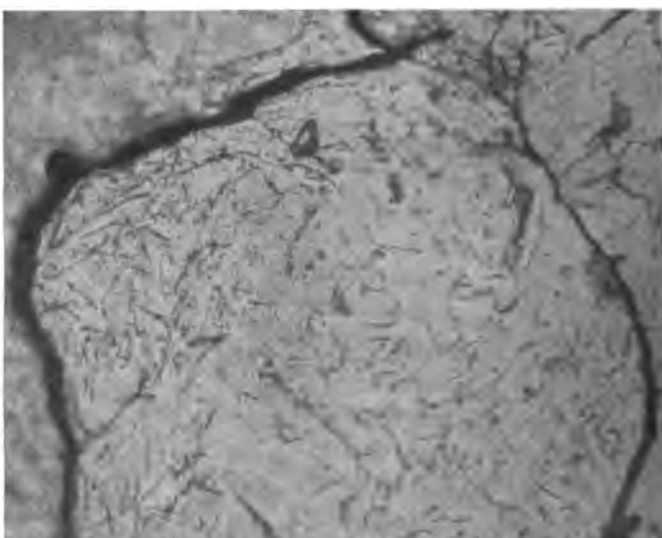


FIG. 13.—GLOBULE OF IRON SURROUNDED BY FILM OF OXIDE. STRAIN HAS OPENED THE CRACK. × 430.

SPECIMEN 106.

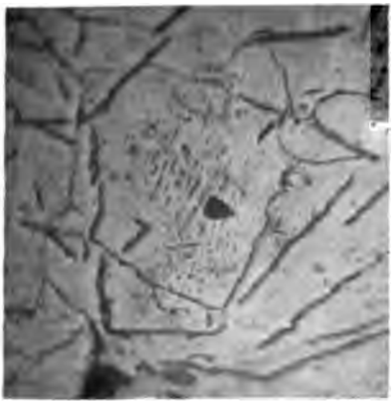


FIG. 14.

FIG. 15.

FIG. 14.—SECONDARY SET OF LINES IN GRAIN. PRIMARY SET IN N. E. AND S. W. CORNERS WHERE THE SECONDARY LINES ARE ABSENT. THIS STRUCTURE ALSO OCCURS IN N-IZED IRON. FIRST TIME NOTICED IN ELECTRIC WELD. × 1200.

FIG. 15.—THE LARGE PLATE FOR SOME REASON HAS A WIDE GROOVE ON ONE SIDE. THE SLIP BANDS CROSS THE PLATE AND EXTEND ON OTHER SIDE. × 1200.

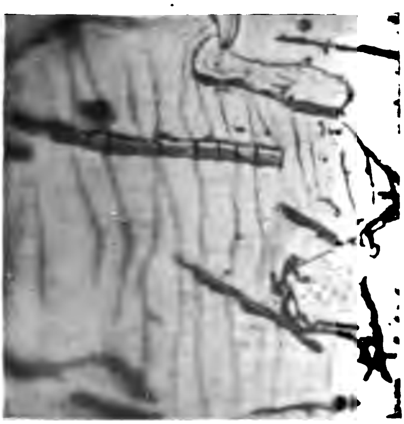


FIG. 16.

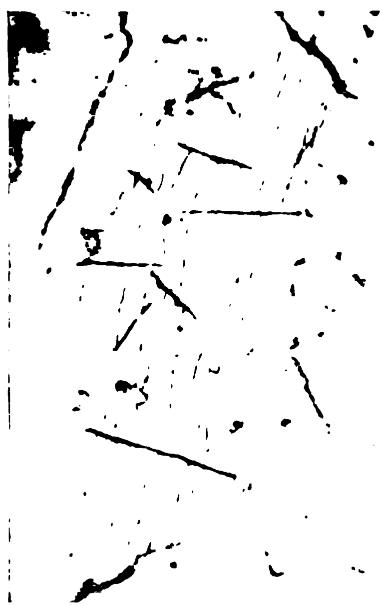


FIG. 17.

FIG. 16.—THIS ENLARGED VIEW OF FIG. 15 SHOWS SLIP BANDS PASSING TO BOTTOM OF GROOVE, THROUGH PLATE, WHICH IS BROKEN IN NUMEROUS PLACES, RISING ON THE OTHER SIDE, AND CONTINUING THROUGH FERRITE. STEPS, DUE TO SLIPPING, ARE CLEARLY VISIBLE, THOUGH THEY ARE ROUNDED AND NOT LIKE SAW TEETH. × 2400.

FIG. 17.—SLIP BANDS PAY NO ATTENTION TO LINES, BUT CROSS THEM AT TIMES, AND AGAIN STOP AT THEM, NO MATTER WHAT THEIR DIRECTION. × 430.

necessary and that it varies greatly even under apparently the same conditions.

The etching has been done with a 2 per cent. solution of nitric acid in absolute alcohol and has been carried far enough to show the grain boundaries. The result of this heavy etching is to roughen the grains and produce structures that must be interpreted with care. However, as the object was to locate the grain boundaries, no attention has been paid to the structures shown by heavy etching unless they were checked by normal etching with both picric and nitric acids. In some cases, espe-

SPECIMEN 106.

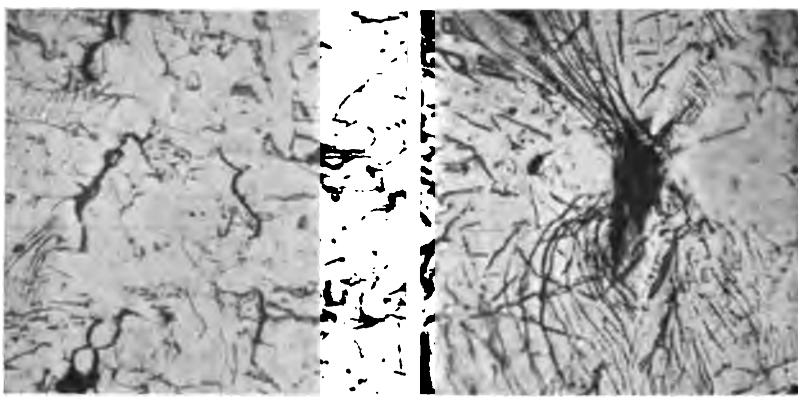


FIG. 18. FIG. 19.

FIG. 18.—GRAIN BOUNDARY RUPTURES. × 430.

FIG. 19.—SLIP BANDS INTEGRATING AT DEFECT, WHICH IS PROBABLY A GAS POCKET. × 430.

It may be that in electric welds some of the grain boundary ruptures are caused by invisible films of oxide. It is sure that such ruptures usually occur where there is no prior evidence of such films; but there are sometimes spots that seem porous or unsound, and oxide films may exist in their vicinity. It is well to distinguish between obvious oxide defects and grain boundary ruptures due to other causes. The first evidences of strain in any weld are distortions at visible defects.

cially where the grains are columnar, the orientation appears to be practically the same in many grains, and it is very difficult to show the grain boundaries, even by very heavy etching. In such cases, heat tinting is sometimes of advantage, although this does not always show the difference between the grains.

While speaking of the grain boundaries, it may be well to call attention to a condition that is brought out by heavy etching, and which was particularly examined in specimen 4C4. Fig. 22 shows, at low power, the structure of the greater part of the weld; it seems quite clear that there are ferrite boundaries between the grains. The bodies of these grains appear to consist of ferrite with pearlitic lines along the cleavage planes; these are shown at higher power in Fig. 23. After deeper etching,

SPECIMEN 4C4.

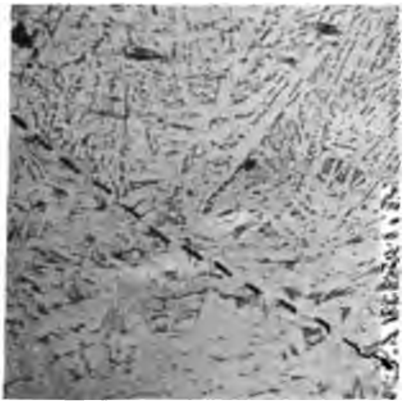


FIG. 20.

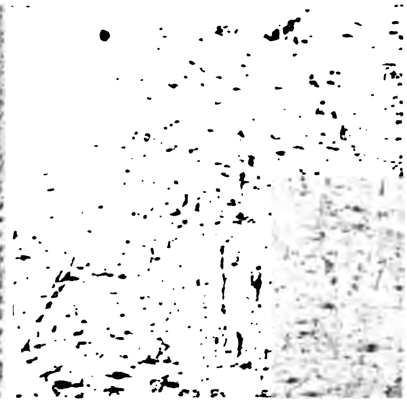


FIG. 21.

FIG. 20.—ON LINE OF WELD WHICH IS ABOVE DOTTED LINE. MUCH CARBON IN WELD. × 100.

FIG. 21.—ORIGINAL MATERIAL MELTED DOWN; IT IS NEARLY FREE FROM CARBON. VIEW IN BOTTOM OF WELD. × 100.

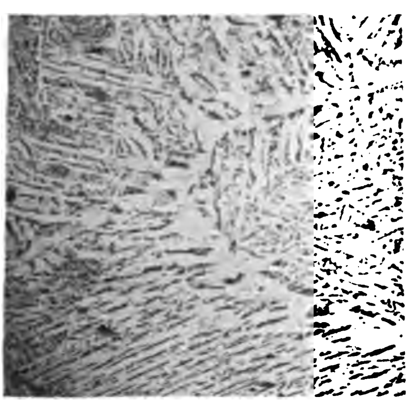


FIG. 22.

FIG. 23.

FIG. 22.—VIEW IN WELD AT TOP. MUCH CARBON. FERRITE LINES ARE PROBABLY MAIN GRAIN BOUNDARIES. × 100.

FIG. 23.—ENLARGEMENT OF FIG. 22, SHOWING PEARLITE. × 430.

SPECIMEN 4C4.


FIG. 24. FIG. 25.

FIG. 24.—HEAVIER ETCHING SHOWS GRAIN BOUNDARIES CLEARLY, WHERE ORIENTATION CHANGES, AND SECONDARY GRAIN BOUNDARIES IN S. E. CORNER. $\times$ 430.

FIG. 25.—SECONDARY GRAIN BOUNDARIES CLEAR; THE ORIENTATION IN THESE GRAINS IS PROBABLY THE SAME. $\times$ 430.

The author thinks these secondary grain boundaries are caused by leaking out of solution of Fe_3C., time not being given for it to segregate. In some cases there is enough of it to make pearlite, in others only enough to appear as cementite and in other cases the films may be ultramicroscopic.

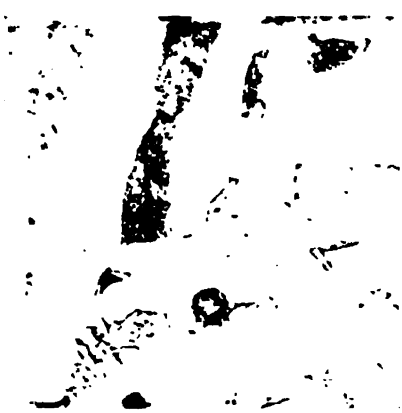
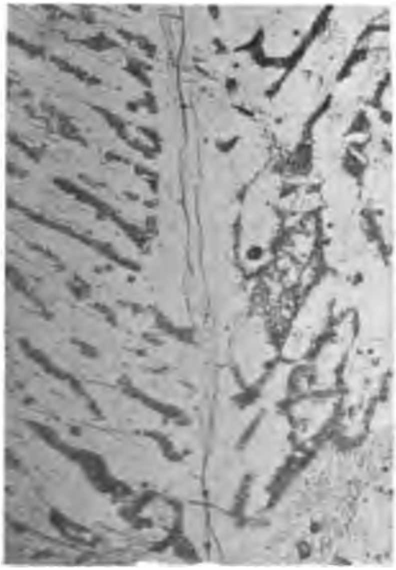



FIG. 26. FIG. 27.

FIG. 26.—WHAT APPEARS AS PEARLITE AT LOW POWER HAS TWO ASPECTS AT HIGHER POWER. ONE VERY FINE GRAINED AND THE OTHER WITH DIVORCED CEMENTITE. $\times$ 1200.

FIG. 27.—UNDER STRAIN RUPTURE BEGINS AT MAIN GRAIN BOUNDARIES. SLIP BANDS IN ADJACENT FERRITE. $\times$ 430.

SPECIMEN 4C4.



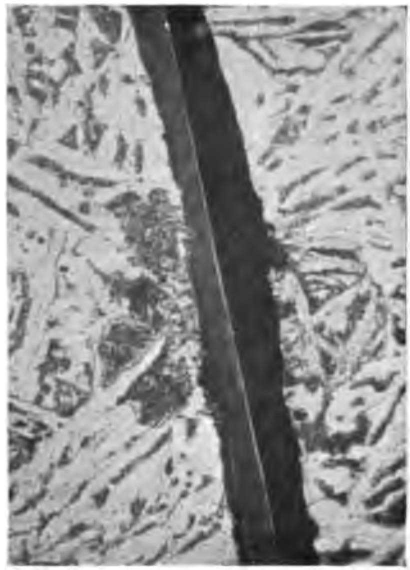
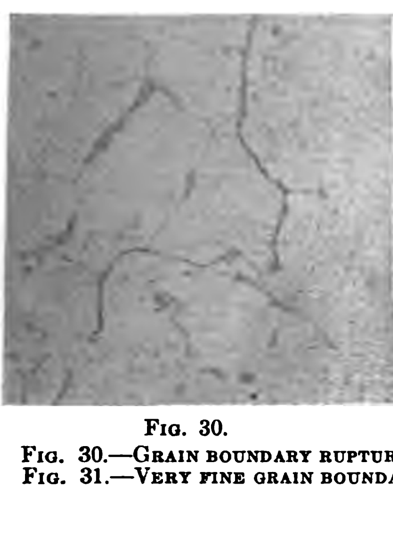


FIG. 28. FIG. 29.

FIG. 28.—ANOTHER MAIN GRAIN BOUNDARY RUPTURE WITH ADJACENT SLIP BANDS. THIS IS VERY COMMON IN THIS WELD. × 430.

FIG. 29.—ABOUT ONE-THIRD OF A RUPTURE. BOTH SIDES PHOTOGRAPHED AS THEY WERE NOT IN THE SAME PLANE. RUPTURE PASSES AROUND PEARLITE AND IS ENTIRELY IN FERRITE. × 430.



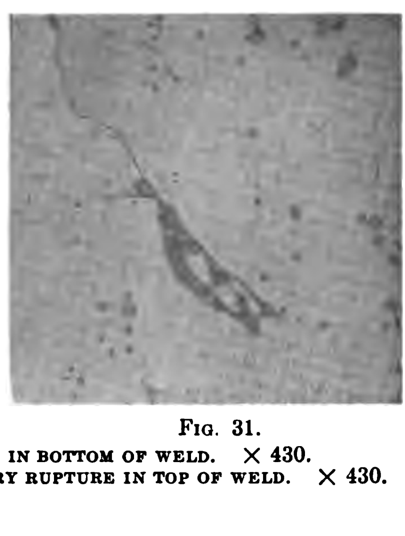


FIG. 30. FIG. 31.

FIG. 30.—GRAIN BOUNDARY RUPTURE IN BOTTOM OF WELD. × 430.

FIG. 31.—VERY FINE GRAIN BOUNDARY RUPTURE IN TOP OF WELD. × 430.

there appear boundaries of what are apparently smaller grains, and it is noticeable that these boundaries are clear and distinct where the orientations of the grains change, as shown in Fig. 24. In places where the orientation may be the same, as shown by the parallelism of the pearlite plates, it is usually difficult to see the grain boundaries, but sometimes this can be done, as in Fig. 25. The structure of what appears to be pearlite is shown at higher power in Fig. 26. There appear to be two varieties; in one the eutectoid is very fine, and in the other the cementite is clearly visible as such.

While this structure is from an oxyacetylene weld, electric welds are quite similar in appearance, though the eutectoid is probably not pearlite;

SPECIMEN 4C4.

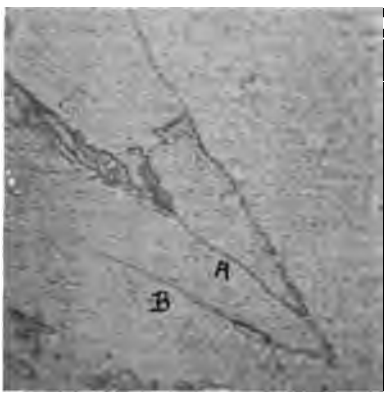


FIG. 32.

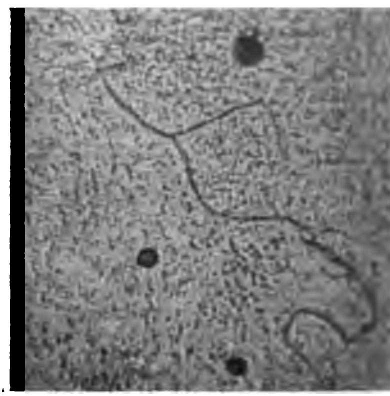


FIG. 33.

FIG. 32.—FILMS OF CEMENTITE. THE ONE AT A IS VERY THIN. THE ONE AT B RUNS OUT TO NOTHING AND IS 0.00001 IN. THICK NEAR THE END. × 1200.

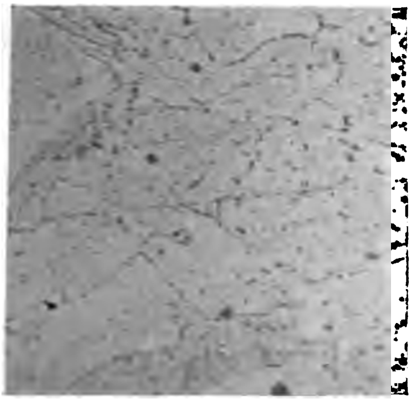
FIG. 33.—VERY FINE GRAIN BOUNDARY RUPTURE. AT ITS UPPER PART MINUTE FILMS ARE VISIBLE WHICH ARE APPARENTLY CEMENTITE. × 1200.

Further strain increased ruptures at ferrite grain boundaries both in size and number. Also the ruptures like Figs. 30, 31, and 33 increased. There were no ruptures through the pearlitic zone or along secondary grain boundaries.

Figs. 8 and 80. It should be remembered that oxyacetylene welds made with low-carbon material do not show this columnar structure nearly so much, and that these secondary grain boundaries, if they may be so called, have not been noticed, the grain size and structure being as in Figs. 46, 47, and 48. It should also be understood that almost any structure can be found in any weld and that the statements just made are the author's observation of the usual condition, to which there are exceptions.

The author feels that, in the present case, it is difficult to describe what occurs during the testing, and, therefore, has given most of the information with the photographs. His conclusions from his examina-

SPECIMEN Q



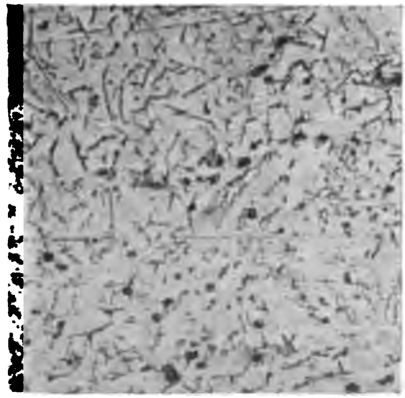
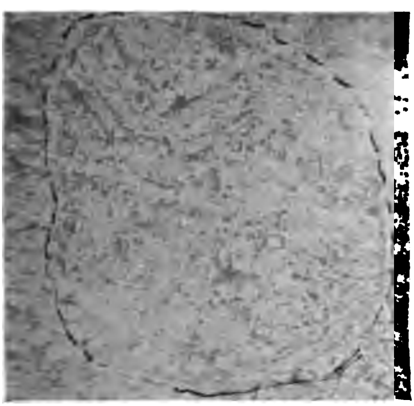


FIG. 34. FIG. 35.

FIG. 34.—STRUCTURE IN LOWER PART OF WELD, WHERE GRAIN SIZE HAS BEEN ALTERED BY HEAT FROM UPPER LAYER. NO LINES IN GRAINS, BUT SOME SPOTS AT GRAIN BOUNDARIES. × 430.

FIG. 35.—USUAL STRUCTURE OF REST OF WELD. LINES AND SPOTS AS USUAL. MORE OXIDE SPOTS THAN IN FIG. 34. × 430.



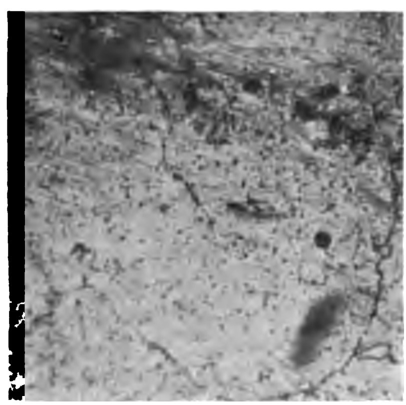


FIG. 36. FIG. 37.

FIG. 36.—ONE OF NUMEROUS SIMILAR DEFECTS IN THIS WELD. VERY THIN FILM OF OXIDE AROUND GLOBULE OF METAL. LINE OF OXIDE JUST INSIDE DOTTED LINE. × 430.

FIG. 37.—ANOTHER SIMILAR DEFECT, WITH GAS POCKET OR POROSITY AT N. W. CORNER. × 430.

SPECIMEN Q.

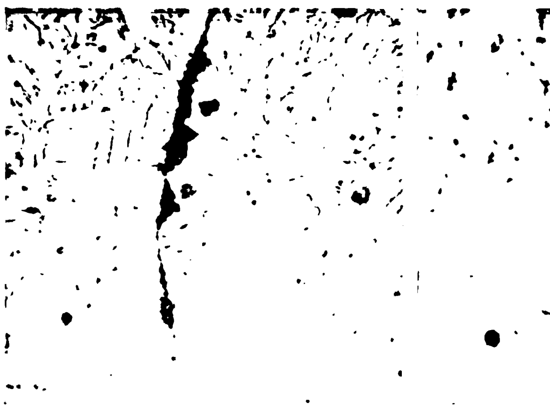


FIG. 38. FIG. 39.

FIG. 38.—ANOTHER OXIDE FILM. ABOUT ONE-TENTH OF IT SHOWN. × 430.
FIG. 39.—FIRST STRAIN OPENS UP DEFECTS. ABOUT ONE-QUARTER OF DEFECT SHOWN. × 430.

FIG. 40. FIG. 41.

FIG. 40.—IN BOTTOM OF WELD, METAL BREAKING AWAY FROM SLAG. × 430.
FIG. 41.—RUPTURE AT LINE OF OXIDE SO MUCH BELOW METAL SHOWN THAT IT IS ENTIRELY OUT OF FOCUS. × 430.

SPECIMEN Q.

FIG. 42. FIG. 43.

FIG. 42.—SURROUNDING METAL IN FIG. 41 FOCUSED. OPENING OF CRACK AND ITS EXTENSION S. E. SHOWN. × 430.

FIG. 43.—FURTHER STRAIN OPENS DEFECTS MORE. SAME FIELD AT FIG. 39. × 430

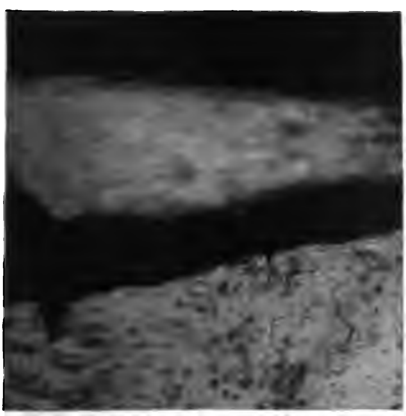


FIG. 44. FIG. 45.

FIG. 44.—RUPTURES AT RIGHT ANGLES TO LINE OF STRAIN ARE SOMETIMES FOUND, ESPECIALLY AT DEFECTS. AT BOTTOM OF FIGURE IS METAL, THEN RUPTURE, THEN MORE METAL, OUT OF FOCUS, ITS TOP EDGE BEING THE TOP OF THE WELD. × 430.

FIG. 45.—SLIP BANDS AT UPPER END OF RUPTURE IN FIG. 39. × 430.

In this weld there were 16 defects visible before applying strain, the area examined was 1/4 in. × 3/8 in. It is perfectly possible to do much better than this, if proper electrodes and current are used, and care is taken.

This weld has been used as an illustration of what is necessary to avoid; that is, freedom from even microscopic defects is necessary for the best work.

SPECIMEN RA1.

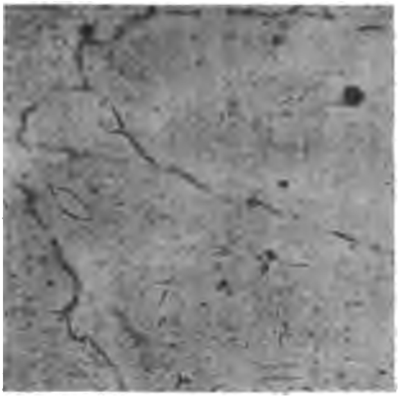


FIG. 46.

FIG. 47.

FIG. 46.—GRAIN SIZE AND SHAPE. LARGER THAN IN CF2 AND NOT COLUMNAR. × 430.

FIG. 47.—STRAIN CAUSES SLIP BANDS, NOT GRAIN BOUNDARY RUPTURES. × 430.

FIG. 48.

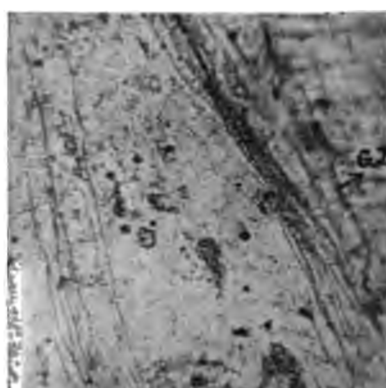


FIG. 49.

FIG. 48.—FURTHER STRAIN INCREASES NUMBER OF SLIP BANDS WHICH HERE CROSS GRAIN BOUNDARY. × 430.

FIG. 49.—SLIP BANDS INTEGRATE INTO GROOVES OR DIFFERENCES IN LEVEL, BUT MISS GRAIN BOUNDARIES AS SHOWN. × 430.

SPECIMEN RA1.

FIG. 50.

FIG. 51.

FIG. 50.—SLIP BANDS DO NOT HERE CROSS GRAIN BOUNDARY. THE NEARLY VERTICAL LINE IS A SCRATCH. × 430.

FIG. 51.—FURTHER STRAIN INTEGRATES SLIP BANDS INTO A GRAIN BOUNDARY RUPTURE. THIS IS THE ONLY CASE NOTICED WHERE RUPTURE WAS AT GRAIN BOUNDARY. × 430.

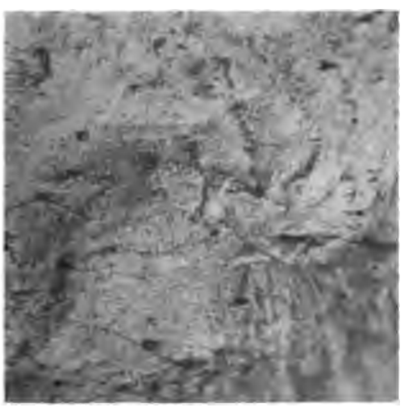


FIG. 52.—WITH FURTHER STRAIN SURFACE BECOMES ROUGH AND UNEVEN DUE TO MANY SLIP BANDS, ETC. BUT THERE IS STILL NO EVIDENCE OF GRAIN BOUNDARY RUPTURES. × 430.

SPECIMEN RE2.

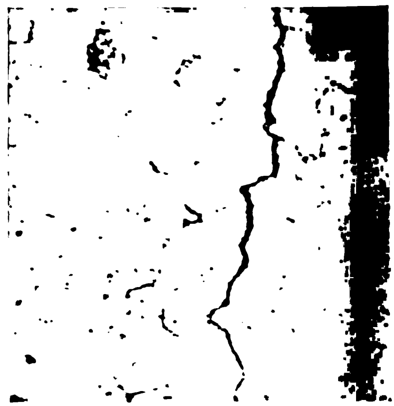
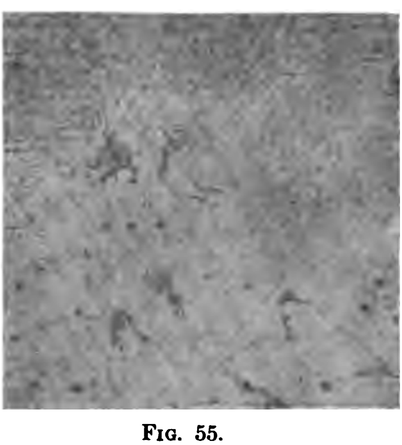


FIG. 53. FIG. 54.

FIG. 53.—GRAIN SIZE AND SHAPE SIMILAR TO CF2. QUITE A LITTLE PEARLITE. GRAINS COLUMNAR. × 430.

FIG. 54.—GRAIN BOUNDARY RUPTURES APPEAR WITH SLIGHT STRAIN. × 430.



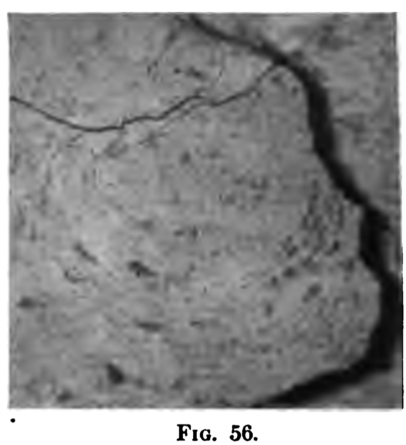


FIG. 55. FIG. 56.

FIG. 55.—SLIP BANDS APPEAR ALSO, BUT THEY ARE VERY FINE. × 430.

FIG. 56.—LARGE DEFECT APPEARED AT FIRST STRAIN. FURTHER STRAIN CAUSED IT TO OPEN MORE, AND STARTED SMALLER CRACK SHOWN. BOTH AT GRAIN BOUNDARIES. × 430.

tions, not only of the specimens mentioned but of a number of others, are as follows:

1. The first evidence of strain in any weld is at whatever visible defects may exist in the weld, such as films of oxide around the grains, or around small particles of metal as in electric welds. This is well shown in Figs. 7, 13, 39, and 40. The latter defects are very common in electric welds, as in Figs. 36, 37, and 38; and the films are sometimes very thin, as in Fig. 36. It will be noticed from the table that the welding materials low in carbon appear to give a much less columnar structure in gas welds than the others, compare Figs. 46, 5, 53, and 60; this, however, is difficult to prove by photographs. Also, in electric welds, the structure is usually

SPECIMEN RE2.

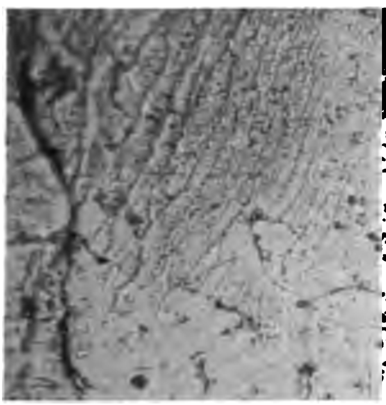


FIG. 57.

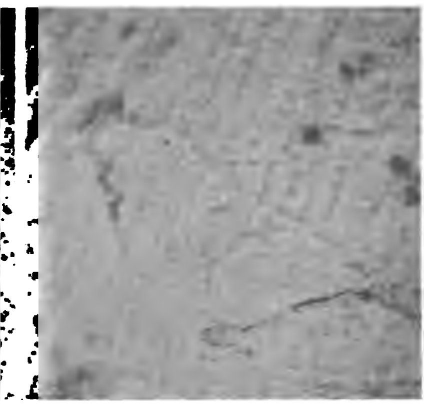


FIG. 58.

FIG. 57.—SLIP BANDS INCREASE RAPIDLY WITH FURTHER STRAIN AND SOMETIMES CROSS GRAIN BOUNDARIES. × 430.

FIG. 58.—ENLARGED VIEW OF FIG. 57. NINE SLIP BANDS CROSS GRAIN BOUNDARY. THEY COULD NOT ALL BE PHOTOGRAPHED AT ONCE. × 1200.

RE2 seemed more brittle than CF2; that is, more ruptures appeared, and less strain was needed to cause them. Slip bands seemed to increase more rapidly than in CF2, but less rapidly than in RA1. As in CF2, grain boundary ruptures cause most of the distortion.

more columnar than in gas welds; although variations can be noticed here also. It would appear that the rapid cooling of electric welds is responsible for this and that the slower cooling of gas welds probably make the grains more nearly equiaxed. Again, any material that preserves the pearlitic structure in a gas weld, such as vanadium or manganese, seems to produce more columnar grains. Aluminum, in considerable quantities in electric welds, makes the grains excessively columnar, the structure being shown in Fig. 80, and very large, their columnar appearance in the fracture being noticeable to the naked eye.

2. If there are no defects in the weld, the first appearance of distortion varies with the kind of weld and the material with which it is made.

Specimen CF2.

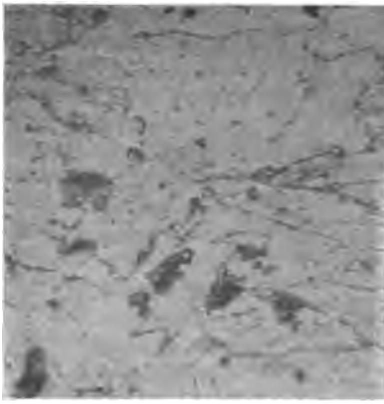


Fig. 59.

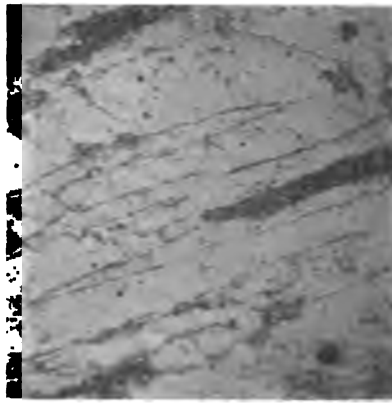


Fig. 60.

Fig. 59.—Grain shape and size varies from this to Fig. 60. × 430.
Fig. 60.—Columnar grains of ferrite and pearlite. × 430.

In both of these there is considerable pearlite and cementite along grain boundaries, due to vanadium in welding rod. The grains are also small compared with RA1.

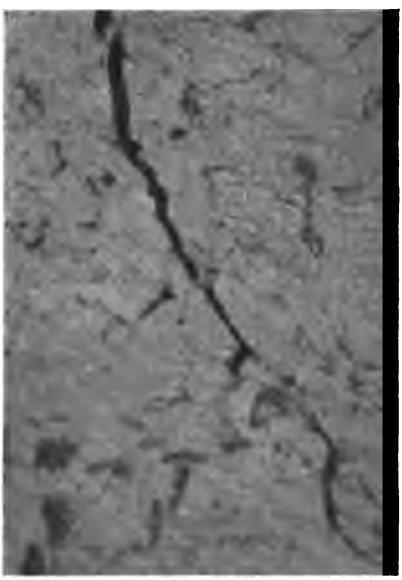


Fig. 61.

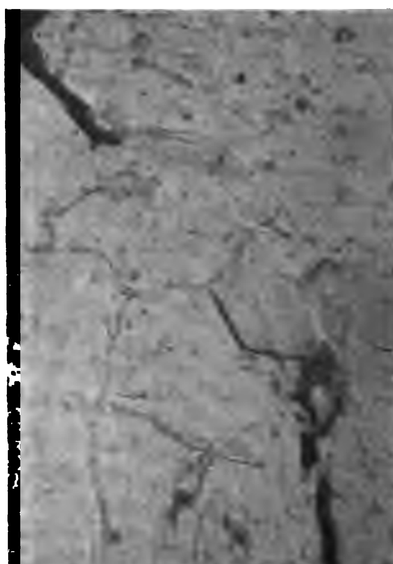


Fig. 62.

Fig. 61.—Grain boundary rupture after moderate strain. × 430.
Fig. 62.—Another grain boundary rupture with slip bands at end of crack running parallel to grain boundary. See Figs. 64, 66, and 72. × 430.

SPECIMEN CF2.

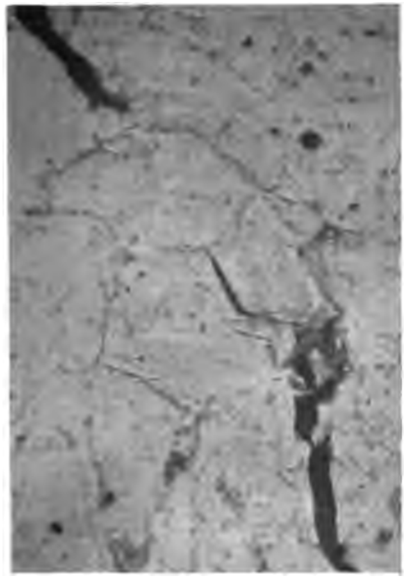


FIG. 63. FIG. 64.

FIG. 63.—ANOTHER GRAIN BOUNDARY RUPTURE. × 430.
FIG. 64.—FURTHER STRAIN OPENS RUPTURES FURTHER, AND SHORT STRAIGHT RUPTURE BEGINS TO CROSS GRAIN BOUNDARY. × 430.

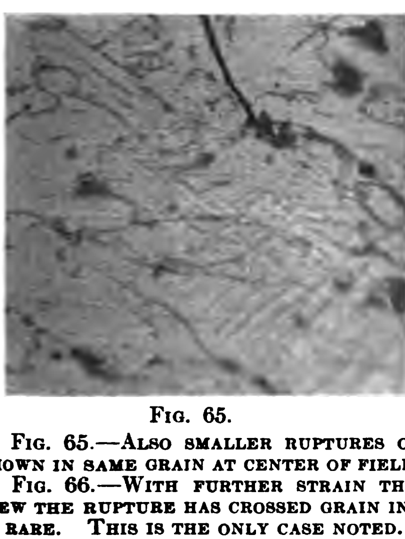


FIG. 65. FIG. 66.

FIG. 65.—ALSO SMALLER RUPTURES OCCUR, SLIP BANDS INCREASE. TWO SETS SHOWN IN SAME GRAIN AT CENTER OF FIELD WHICH IS NEAR BOTTOM OF WELD. × 430.
FIG. 66.—WITH FURTHER STRAIN THE RUPTURES BECOME WIDER AND IN THIS VIEW THE RUPTURE HAS CROSSED GRAIN IN CENTER. SUCH A CROSSING OF THE GRAIN IS RARE. THIS IS THE ONLY CASE NOTED. SLIP BANDS ALSO INCREASE. × 430.

SPECIMEN CF2.

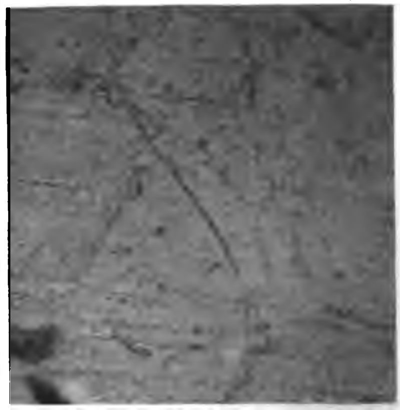


FIG. 67. FIG. 68.

FIG. 67.—GRAIN BOUNDARY RUPTURE IN FIG. 63 EXTENDS AND SLIP BANDS APPEAR IN GRAIN. × 430.

FIG. 68.—FURTHER RUPTURES OCCUR AT GRAIN BOUNDARIES. × 430.

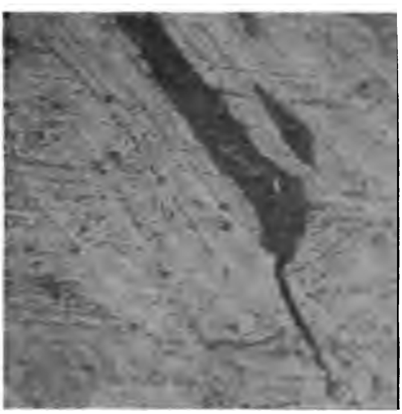


FIG. 69. × 430. FIG. 70. × 1200.

Grain boundary rupture extending into pearlite. In larger view, end of pearlite at rupture shows to be below surface and as slip bands do not appear to be large enough to equal the width of the crack, it would seem that slip has also occurred in the pearlite.

In oxyacetylene welds, made with pure iron or low-carbon material, in which practically all the carbon is burnt out during the welding, and where there is but little if any manganese or vanadium, slip bands appear in the grains first, as in the various photographs of specimen RA1. These slip bands at times cross the grain boundaries, as in Fig 48, and at other times stop at the grain boundaries, as in Fig. 50. They appear to increase in number and form cracks, as in Figs. 49 and 51; but there is seldom any evidence of rupture at the grain boundaries; in

SPECIMEN CF2.

FIG. 71.

FIG. 72.

FIG. 71.—GRAIN BOUNDARY RUPTURE PASSING THROUGH PEARLITE, THE ONLY CASE NOTICED. × 1200.

FIG. 72.—FURTHER INCREASE IN WIDTH OF RUPTURE AND IN SLIP BANDS; SEE FIGS. 62, 64, AND 66. × 430.

While many slip bands appear in CF2, they are very fine, and distortion increases at grain boundaries rather than by slip bands.

Fig. 49 the grain boundary is shown to the right of the set of slip bands. Fig. 51 shows what at first appears to be a grain boundary crack, but much of it is really nothing but an accumulation of very fine slip bands. Eventually the surface becomes a mass of slip bands and folds, as in Fig. 52; after which it becomes impossible to determine where the final rupture occurs though it is doubtless along some of the slip bands.

3. In all electric welds and in oxyacetylene welds made with material containing considerable carbon, say 0.4 per cent., or in which other elements such as manganese and vanadium are in sufficient quantity to maintain a pearlitic structure even with lower carbon, which structure

SPECIMEN EWN—NORMALIZED FROM 900° C.

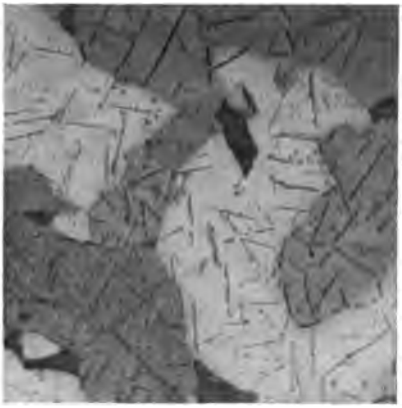


FIG. 73. FIG. 74.

FIG. 73.—GENERAL STRUCTURE. HEAT-TINTED AFTER ETCHING. DARK PATCHES AND LINES ARE PURPLE. LINES CLEARER THAN IN WELD. COLUMNAR STRUCTURE DESTROYED. LINES APPEAR SOMETIMES AT GRAIN BOUNDARIES. × 430.

FIG. 74.—ONE OF THE LARGE PURPLE PATCHES WITH DARKER PURPLE MARKINGS INSIDE RESEMBLING MARTENSITE IN SHAPE. THESE MAY CONTAIN SOME CARBON AND APPEAR IN NEARLY ALL PATCHES. LINES SHOW CLEARLY ON GRAIN BOUNDARIES. × 1200.

SPECIMEN EWQ—HEATED FOR 1 HR. AT 900° C. AND QUENCHED IN COLD WATER.

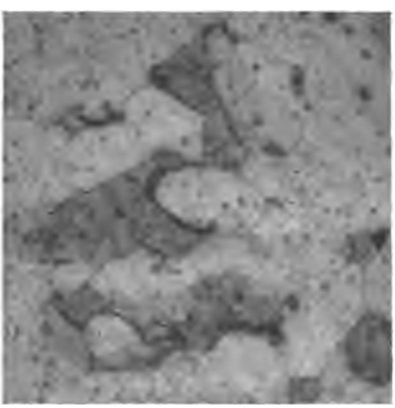


FIG. 75. FIG. 76.

FIG. 75.—GRAINS OF PEARLITIC APPEARANCE ARE POSSIBLY AN IRON-IRON NITRIDE EUTECTOID. LINES IN GRAINS HAVE DISAPPEARED. × 430.

FIG. 76.—EUTECTOID APPEARS VERY FINE GRAINED. SAME AS FIG. 75, BUT × 1200.

SPECIMEN CBE1.

FIG. 77.

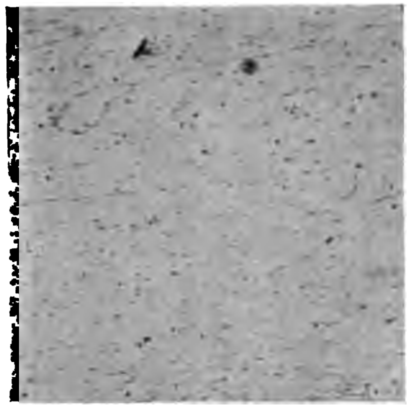


FIG. 78.

FIG. 77.—MATERIAL ON RIGHT, ORIGINAL MELTED DOWN AND DECARBURIZED. MATERIAL ON LEFT, ORIGINAL ALTERED IN STRUCTURE BY THE HEAT. × 100.

FIG. 78.—FILMS AROUND GRAINS IN ORIGINAL MATERIAL MELTED DOWN. × 100.

FIG. 79.

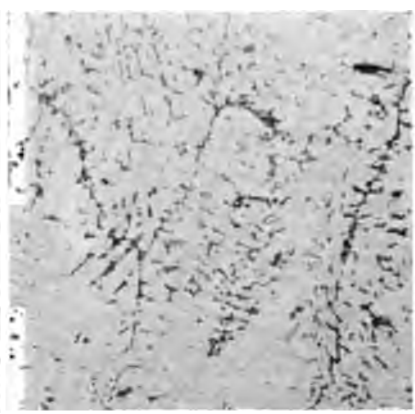


FIG. 80.

FIG. 79.—SAME AS FIG. 78, BUT × 1200. NOTE ONE SPOT WHERE FILM DOES NOT SHOW. IT IS THERE PROBABLY TOO FINE TO BE SEEN. THE FILMS ARE PROBABLY Fe_3C.

FIG. 80.—LARGE COLUMNAR GRAINS IN ADDED MATERIAL. THIS IS USUAL STRUCTURE OF THIS WELD. × 100.

is also quite columnar and resembles that of electric welds, the path of rupture is invariably along the grain boundaries.

These conclusions apply only to welds as made and not to those that have been heat-treated. Also, the path of rupture due to shock or

SPECIMEN BS1.

FIG. 81.—STRUCTURE OF LIGHT SPOTS IN COLUMNAR GRAINS. THEIR NATURE IS NOT KNOWN BUT POSSIBLY THEY ARE Fe_3C PRESERVED BY THE ALUMINUM. × 1200.

FIG. 82.—LINES IN TOP OF O. A. WELD RESEMBLING THOSE IN ELECTRIC WELDS, BUT LARGER AND THICKER BECAUSE OF SLOWER COOLING. THEIR NATURE IS NOT KNOWN. THEY MAY BE CAUSED BY ABSORPTION OF NITROGEN AT THE VERY HIGH TEMPERATURE BY THE MELTED METAL. × 1200.

alternating stress may possibly be different from that due to tensile stress. The author will make some tests along these lines later.

These facts are very interesting and evidently have a bearing on the brittleness of certain welds. For instance, it is well known that electric welds are comparatively brittle, but the author has never seen the

statement made that oxyacetylene welds made with material containing 0.15 per cent. carbon and 0.15 per cent. vanadium, or that containing 0.15 per cent. carbon and 0.50 per cent. manganese are just as brittle as electric welds, if not more so. Such oxyacetylene welds are also much higher in tensile strength than welds made with low-carbon material free from manganese and vanadium. Also, welds made with 0.4 per cent. carbon steel with normal amounts of the other usual elements are brittle.

All brittle welds resemble each other in that the structure is more or less columnar and that they contain impurities such as pearlite, cementite, and nitride of iron(?). According to the usual understanding, during the solidification or cooling from high temperature of a metal, impurities are rejected to the grain boundaries. Humfrey, in a very interesting paper[2] on the intercrystalline fracture of steel has shown that intercrystalline rupture can be caused by overheating, and that proper heat treatment restores the tendency to rupture across the grains in the normal way. The author is of the opinion, from rough tests he has made, that the brittleness in gas welds at least can be removed by similar heat treatment. He is not so sure of electric welds, because their heat treatment, at least in any ordinary way, does not remove the line structure, as shown in Fig. 73, in which, in many cases, the lines lie either on or very close to the grain boundaries. Fig. 74 shows some of these lines directly on the grain boundaries.

There are also, in welds so treated, and which have been heat-tinted after etching, patches lying at the grain boundaries; these are purple when the surface of the specimen is a light brown. The lines also are purple. These purple patches usually, but not always, contain zigzag lines of a still darker purple, as shown in Fig. 74. The author does not know the nature of these zigzag lines and purple patches, but inasmuch as similar patches in unannealed welds darken when boiled in sodium picrate, he thinks that they contain carbon. The purple patches are probably nitride of iron, which heat-tints purple when pure.

The quenching of electric welds appears to produce an entirely different structure, as shown in Figs. 75 and 76. The grains here, as in the the normalized specimen, have lost their columnar nature, as would be expected, and the lines have entirely disappeared, the nitride of iron apparently forming a eutectoid with some of the iron. These photographs show the necessity of further investigation. Andrew has shown that nitrogen, in sufficient quantity, suppresses the critical points, so that it is a question as to the exact conditions under which these changes occur.

It seems quite clear that the only way to account for the brittleness

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[2] *Carnegie Schol. Mem.*, Iron and Steel Inst. (1912) 4, 80–107.

of welds is to assume that it is caused by films of material at the grain boundaries, the nature of these films differing in different welds. In specimen CBE1, made by the carbon-arc process, there is one spot where the original material was melted down and decarburized by the heat, in which there are very faint films around the grains, as shown in Figs. 78 and 79. These films are evidently cementite trapped at the grain boundaries by the rapid cooling. They are 0.00002 in. thick in places, and in spots where they cannot be seen it would seem entirely reasonable to suppose that they exist, but are ultra-microscopic. Similarly, specimen 4C4 shows in many places very thin films of cementite of the same or even less thickness as shown in Figs. 32 and 33.

It would not seem probable that in metallic electrode welds such films would be of cementite, as the carbon is almost entirely burned out; they may be nitride of iron. It is also possible that, as Humfrey suggests in the paper referred to, they are oxide of iron. Fig. 6 shows comparatively thick films of iron oxide in an oxyacetylene weld, in which there were nests of these films in many places. Evidently crystallization cannot proceed through these films, whatever their nature, nor does it seem possible that amorphous material could exist there. It is quite probable that where the films are cementite, they could be absorbed by heat treatment. This could occur when the films are nitride of iron and probably is impossible when they are oxide of iron. It seems quite plausible that these films could be of ultra-microscopic thickness; and as all of them are brittle, they would be very weak under shock and probably under alternating stress, although their thinness might account for the high tensile strength of the welds in which they exist, on the same principle that a thin film of glue is stronger than a thick film. It might be mentioned that metal electrode welds have sometimes a tensile strength as great as 70,000 lb. per sq. in. (49.19 kg. per sq. mm.) and would probably have this always if they were sound. Oxyacetylene welds made with low-carbon material have much greater ductility and resistance to shock because of the absence of these films; and it appears probable that, within limits, the purer the material the more ductile such a weld will be.

While the author questions whether anything but circumstantial evidence can ever be adduced for his belief in the presence of these films, the facts are that, under welding conditions, very thin films that are visible do exist; and that with welds containing impurities, the breakage is always at the grain boundaries where it is known that impurities collect. So he sees no reason to doubt their existence and believes that they are responsible for the brittleness of such welds.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Static, Dynamic, and Notch Toughness

BY SAMUEL L. HOYT,* E. M., PH. D., MINNEAPOLIS, MINN.

(New York Meeting, February, 1919)

SOME of the more important properties of finished materials are strength, ductility, toughness, resistance to alternating and repeated stresses, etc. Of these, the property that appears to have received the least consideration, at least in this country, is toughness, which is due, possibly, to our regarding toughness as a qualitative property or, at any rate, as one that parallels ductility. This arises out of our greater experience with the simple carbon steels in the rolled or forged (non-heat-treated) condition which, qualitatively, are tough if ductile and are not tough if brittle. In this way we have erroneously become accustomed to judging the toughness of a material from its behavior in the tensile or similar test.

The point of view presented in the present paper is that toughness, like hardness or tensile strength, should be regarded as an independent property and of sufficient importance to require, in so far as that may be possible, quantitative determinations. If such be true, it becomes at once necessary to devise experimental means for measuring or valuating toughness, and the notched-bar impact test (the Charpy test) is advanced as the most logical test that has so far been developed for this purpose. It is further advanced, with particular emphasis, that we have two kinds of toughness to deal with and, accordingly, they will be dealt with independently.

Classification of Materials According to Toughness

Toughness has been defined somewhat as follows: Tough materials are those that offer considerable resistance to permanent deformation but which, once such resistance has been overcome, may be deformed plastically, but only by the expenditure of considerable energy. In other words, tough materials may be deformed plastically but they absorb a considerable amount of work in the process. This kind of toughness may be called "static" toughness when the rate of loading is reasonably slow or "dynamic" toughness when the rate of loading is

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comparatively rapid, as in impact testing, but in all cases the stress distribution is essentially uniform. However, static toughness does not imply resistance to shock, or dynamic toughness. In fact, dynamic toughness may be equal to, greater than, or less than the static toughness, thus dividing materials into three classes. This is well shown by numerous cases on record.

Tests on the resistance to impact of cast-iron bars, as made by Russell,[1] indicate that cast iron is nearly one-half again as resistant under impact as it is under static loading, using for the comparison the amounts of work absorbed in producing fracture. Considere,[2] working on the dynamic resistance of soft-iron wire, showed that to produce a given deformation greater loads were required if suddenly applied than if slowly applied, but that the total deformation (ductility) remained constant. According to this, soft iron absorbs more work when broken by dynamic loading than by static loading.[3] One of the most notable cases of this kind is that described by De Fréminville[4] in discussing the application of impact testing to the selection of metals for use in machine construction. De Fréminville considered two types of parts according to their behavior under impact, both of which must be made of materials that are highly resistant and able to absorb heavy impacts. The first type must do so and yet not deform appreciably, while the second type is allowed considerable deformation provided the part so stressed is able to retain its original shape when the load is released. During the course of this work, one steel was found that was considerably more resistant under impact than under static loading, and so, for his purpose, was particularly valuable. The ordinary (static) tests failed to bring out the superior quality of this steel. The type of materials that has practically the same behavior under static and dynamic loading is fairly large, as has been shown by the work of Breuil,[5] Hatt,[6] Frémont,[7] Charpy,[8] and Martens.[9]

Tests on the third type of materials, which possess remarkably low

[1] S. Bent Russell: Experiments with a New Machine for Testing Materials by Impact. *Trans.* Amer. Soc. Civil Engineers (1898) **39**, 237.

[2] Contrib. à l'étude de la Fragilité dans les Fers et les Aciers, p. 3.

[3] This, of course, does not mean that the material can stand repeated loads greater than the known tensile strength even though they be applied suddenly.

[4] Contrib. à l'étude de la Fragilité dans les Fers et les Aciers, p. 475.

[5] Pierre Breuil: Abstract of paper on effects of stresses. *Jnl.* Iron and Steel Inst. (1904, No. 1) **65**, 413.

[6] W. Kendrick Hatt: Tensile Impact Tests of Metals. *Proc.* Amer. Soc. Test. Mat. (1904) **4**, 282.

[7] Contrib. à l'étude de la Fragilité dans les Fers et les Aciers, p. 150.

[8] Ibid., p. 213.

[9] Adolf Martens: Handbook of Testing Materials, translation by G. C. Henning, 233. John Wiley & Sons, New York, 1899.

resistance to impact, were carried out by Considere[10] who brought out some very interesting points in connection with the dynamic properties of metals. The resistance to impact of soft-iron wire under shear and under tension was measured with varying velocities of impact by gradually increasing the height of drop of the weight producing the impact. It was found that the resistance to impact increased directly with the velocity of the impact up to and even beyond that velocity which was sufficient to cause the rupture at one blow. By still further increasing the height of drop, a velocity was reached at which the material broke suddenly with very low impact resistance and with negligible deformation. At velocities above this critical velocity, the resistance to impact is obviously much inferior to the static strength. By increasing the weight to a certain (critical) amount, the resistance to impact decreased sharply as soon as the velocity was sufficient to cause the rupture with one blow.[11] In such a case, heavy impacts are much more dangerous than light impacts even though the amount of energy expended is the same in both cases. Temperatures from $-10°$ C. to $150°$ C. were found to have only a minor (primary) influence, but a very important secondary temperature influence was found, inasmuch as low temperatures caused a marked lowering of the critical velocity. These tests served also to bring out the inferiority, under impact, of hard-drawn iron wire as compared to annealed wire. Under static loading, the tensile strength of the unannealed wire was greater than that of the annealed wire, but under impact both the deformation and the tensile strength were less for the unannealed wire, which shows that in certain cases a high static tensile strength is not a sufficient guarantee of strength.

Notch Toughness

It is well known that a stress applied to a bar that has a sudden change in cross-section along its length produces a decidedly non-uniform strain distribution at the change in cross-section. If the change in cross-section is in the form of a nick or a groove, the strains at the base of the nick multiply and are much greater than the average strain over the cross-section. Such a nick, or sudden change in cross-section, is here referred to as a "notch," and the non-uniform strain distribution, as the "notch effect." The ability of a material to withstand stresses when in the notched condition is referred to as its "notch toughness."

The notch effect is well illustrated every time a blacksmith nicks a bar to break it off at any particular point. Even a blow by the hand

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[10] *Loc. cit.*

[11] The work of Considere suggests the advisability of considering all impact testing (weight and velocity of impact) from the point of view of the critical velocity and critical weight here described.

produces strains at the base of the notch well in excess of the resistance of the material and hence produces the fracture. A similar blow on an unnotched bar would merely bend the bar over. Thus it is that a bar, even though made of normally tough material, if notched, may behave as if brittle. Koenigsberger[12] has shown by means of glass models that notches localize the strains and that the neutral axis of a stressed bar runs close to the peak of the notch instead of remaining in the middle section. Heyn[13] has shown that a lead bar cut with a notch has an entirely different strain distribution under bending from that of a similar bar without a notch. The volumes of the strained parts were as 1 : 3.76 and the maximum fiber elongations, measured by the distortion of 5-mm. squares, were 120 per cent. and 70 per cent. for the notched and unnotched bars respectively. But to get a correct idea of the maximum deformation, the extension of the width of a line at the apex of the notch was determined. The original width of the line was 0.25 mm. but after deformation it was found to be 5 mm., which gave a deformation of 1700 per cent. It has also been shown by Leon,[14] that a transverse notch cut in a tensile test bar produces an uneven distribution of strains over the cross-section at the base of the notch, the greatest strains coming at the apex of the notch. These cases illustrate the notch effect as it occurs in ordinary metals, which is to localize the strains in the neighborhood of the apex of the notch, at times to such an extent that they may be far in excess of the resistance of the material under tension. In excessively brittle materials, the multiplication of the maximum fiber stress is even more excessive. An example of a notch in such materials is the small file scratch made on a glass rod to assist in breaking off any particular length.

It is likewise known that the severity of the notch effect increases as the angle of the notch decreases. On this account the notch effect increases in most materials when fracture starts, because the angle of the fracture is generally less than the angle of the original notch. Certain pliable materials, or those that are "self healing," of which lead is an example, behave in the opposite manner, since the notch becomes more rounded with distortion. In the same way a material of high notch toughness is much less dangerously affected by a notch than one with low notch toughness, a point that will receive consideration further on.

Notch Effect in Engineering Practice

The frequency of the notch effect in engineering practice has been brought rather forcibly to the writer's attention in various investigations

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[12] *Proc.* 4th Congress Intern. Assoc. for Testing Materials, Brussels, 1906, Paper C 4 d.

[13] Martens-Heyn: "Handbuch der Materialienkunde." II A, 374. Berlin, 1912. Julius Springer.

[14] *Oester. Wochenschrift f. d. oeffentlichen Baudieust.* (1908) **29**, 43.

of failed parts. It was noted that the notch effect may at times be intentionally introduced through the design of the part (sometimes faulty) and at other times may be unintentionally introduced through faulty or careless workmanship; of these, the latter is the more reprehensible and the more difficult to guard against. Another equally important point is the necessity of considering the microstructure and the desirability of heat treatment as a means of overcoming or counteracting the effect of the notch.

A certain railway company suffered an extraordinary number of splice bar failures, which from the records it was impossible to trace to roadbed conditions. Tests on parts of the failed bars showed that the material was well up to the quality required by the specifications, so that no basis for

Fig. 1. × 65.

Fig. 2.—Same as Fig. 1. × 425.

Original structure of splice bar.

criticism could be made on that score. It contained 0.34 per cent. carbon and 0.018 per cent. phosphorus; it had an elongation of 35 per cent. on 2 in. (50.8 mm.); a tensile strength of 65,200 lb. (29,574 kg.); and a yield point of 33,000 lb. (14,968 kg.). On making a microscopic examination, the steel showed considerable free ferrite, in characteristic Widmannstättian structure, as may be seen from Figs. 1 and 2. Furthermore, the pearlite was of the familiar lamellar type that is characteristic of slowly cooled steels. The idea developed from this examination was that the two rails and the splice bars form a notch and that the structure of the bar was such that it could not always adequately resist the notch effect produced every time a car passed over the rail joint (repeated stresses). The solution of this problem obviously lay in correcting or improving the structure of the splice bar, to which end a series of heat-treatment tests was conducted. By subjecting the bar to a temperature of 900° C. for ½ hr. and quenching in oil, a structure was secured that was princi-

pally sorbite with only a small amount of free ferrite. The tensile strength was increased to 92,000 lb. (41,730 kg.) and the yield point to 45,000 lb. (20,411 kg.) but the elongation was decreased 22.5 per cent. A characteristic structure is reproduced in Figs. 3 and 4, which represent a small piece of a failed splice bar heat-treated in the laboratory. The original coarse Widmannstättian structure is replaced by a network structure,

FIG. 3. × 65. FIG. 4.—SAME AS FIG. 3. × 565.
STRUCTURE OF SPLICE BAR AFTER HEAT TREATMENT.

the major part of which is sorbite, a constituent composed of the original pearlite and most of the original ferrite. Compared to the Widmannstättian structure, sorbite may be said to be highly resistant to the notch effect. By the adoption of heat-treated splice bars the difficulty was eliminated.

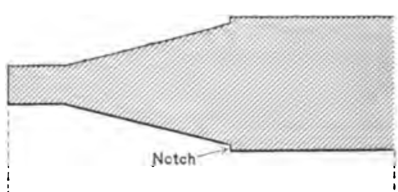

FIG. 5.

Some truck forgings, solid rear axles and steering arms, failed while in heavy service. These parts were made by a well-known automobile axle manufacturing company and suspicion rested at first upon the truck drivers, particularly as the material was known to pass all specifications. It contained 0.485 per cent. carbon; had an elongation of 27.1 per cent. in 3½ in., a reduction in area of 45.6 per cent., a tensile strength of 77,500 lb. (35,153 kg.), and a yield point of 39,900 lb. (17,690 kg.). An examination of the axle (not heat-treated) showed that the taper had

been cut by a roughing tool in such a way as to leave the notch indicated in Fig. 5. Knowing the danger of the presence of such a notch if the steel were in a poor physical condition, a microscopical examination was made; this showed the condition represented in Figs 6 and 7. Here again the

FIG. 6. × 65. FIG. 7.—SAME AS FIG. 6. × 565.
ORIGINAL STRUCTURE OF REAR AXLE.

presence of a relatively large amount of excess ferrite will be noted. The result of a simple oil quench of a part of the failed axle is shown by Fig. 8. While the free ferrite has been largely eliminated and sorbite has been substituted for pearlite, an even better heat treatment would be

FIG. 8.—STRUCTURE OF AXLE WHEN OIL QUENCHED. × 130.

to quench the axle in water, to entirely prevent the segregation of ferrite, and to reheat to produce sorbite and the requisite mechanical porperties.

The danger of a keyseat in an axle is well illustrated by Figs. 9 and 10, which show the extensions of two cracks leading from the angles of the

keyseat. If good engineering practice calls for such a keyseat, the material should be suitably heat-treated to give it a high notch toughness; or, better yet, the material itself, as well as the heat treatment, should be selected with reference to its notch toughness.

An examination of the truck steering arms (which were heat-treated) also revealed the presence of a notch due to defective design or construction of the drop-forging die. Microscopic examination of the failed steering arms showed the heat treatment to have been imperfect inasmuch as granular pearlite, instead of sorbite, was formed which, while

FIG. 9.—LEFT SIDE OF KEYSEAT. × 16.

FIG. 10.—RIGHT SIDE OF KEYSEAT. × 16.

ductile and strong, is not at all a satisfactory structure in the presence of a notch. A similar examination of satisfactory steering arms showed sorbite.

TESTS FOR TOUGHNESS

It has been customary to test materials by various static and dynamic tests and to judge from the strength and ductility whether the quality of the material is sufficiently high to warrant its use regardless of the design of the part, its relationship to other parts, or possible defects due to faulty workmanship. One of the objects of the present paper is to show that, in case the material is to be used in the notched condition. the usual tests are unable to differentiate clearly between materials that will probably stand up and those that are likely to fail. This means that it is necessary to supplement the ordinary tests with a test on notched bars.

In order properly to define what is meant by toughness, it was necessary to distinguish between conditions of uniform and of non-uniform strain distribution. Likewise in testing the toughness of materials the same distinction must be made, a point that, due to its more or less

general disregard, is somewhat strongly emphasized here. A qualitative test for toughness quite commonly used is the nick and fracture test for fiber. This test is useful to a certain extent but it should have no more place in scientific testing of materials than an ordinary scratch test for hardness. The reduction of area in the tensile tests is very frequently looked at with an idea of sizing up the toughness of the material. It is more correctly a measure of ductility and becomes a measure of static toughness only in a limited sense, inasmuch as it is the ability to deform and not the resistance to such deformation that is determined. The area of the stress-strain diagram may be taken as a measure of the static toughness. Such measurements show for example, that the toughness of annealed carbon steels increases with the carbon content up to about 0.3 per cent. C. This figure, combined possibly with the resistance to impact, should be very useful in case the strain distribution of the finished part is essentially uniform. The value obtained by dividing the tensile strength by the proportional limit and multiplying by the elongation (Martens) may be very useful in certain cases; for example, in bringing out the toughness of pure copper. The value of this determination is also limited, as it does not include the resistance with which a material opposes permanent deformation. All of these values are of undoubted importance when properly interpreted, but none would bring out the weakness of the materials in the foregoing examples. In fact, due to their apparent indication of strength and resistance, they would be directly misleading.

The recognition of the peculiar weakness of certain materials when in the notched condition has led to the development of the impact test on notched bars as a supplement to the customary static and dynamic tests and for the express purpose of testing materials for toughness. In its present form, the test is the result of systematic experiments extending over two decades or more by Barba, Frémont, Charpy, Ast, and others, which culminated in the reports of Charpy to the International Association for Testing Materials in 1909 and 1912[15] and of Ehrensberger to the German Society for Testing Materials in 1907.[16] The accumulation of evidence over this period made possible the establishment of a standard test so that now it can be safely stated that the notched-bar test, or in particular the Charpy test, is capable of supplying information relative to toughness that the tensile test gives in but an imperfect, and often in a directly misleading, manner. The test shows the great danger of angular notches or sudden changes in cross-section, particularly when material of low notch toughness is used.

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[15] G. Charpy: Report on Impact Tests of Metals. *Proc.* Int. Assn. for Test. Mat. (May, 1908–Feb., 1910) **1**, No. 5, III_1; Report of Impact Tests and the Work of Committee No. 26 (May, 1910–May, 1913) **2**, Pt. 2, IV_1.

[16] Ehrensberger: *Stahl u. Eisen* (1907) **27**, 1797.

In the report of Ehrensberger, results of tests on three classes of materials were given: forged carbon steels, forged special steels, and cast carbon steels. These three classes of materials can be compared by means of the figures shown in Table 1, which are taken from the report.

TABLE 1.—*Properties of Three Kinds of Steels*

Test No.	Tensile Strength, Pounds per Square Inch	Yield Point, Pounds per Square Inch	Elongation,* Per Cent.	Reduction in Area, Per Cent.	Notched Toughness, Meter-kilograms per Square Centimeter	Remarks
	Forged Carbon Steels					
1	61,500	32,700	26.5	64	4.6	Forged too hot.
2	64,100	36,100	26.0	70	20.4	Correctly forged.
9	71,600	42,000	24.5	70	22.6	
10	71,800	40,000	26.4	60	4.7	Failed railway axle.
25	142,200	93,000	12.1	36	8.5	High carbon.
	Forged Nickel and Chrome-nickel Steels					
51	72,800	58,200	23.3	70	42.1	
69	130,000	108,600	15.1	62	22.1	
71	142,200	118,200	13.3	56	19.3	
75	270,200	232,500	6.5	31	8.3	
	Cast Steel					
161	68,000	37,700	22.9	51	3.7	

* The elongation is for a gage length equal to 10 times the diameter.

A few comparisons may serve to bring out the value of the Charpy test for toughness. Tests 1 and 2 show that the notched-bar test bring out the lack of toughness (or at least notch toughness) of test bar 1, which was forged too hot, although no evidence of this was given by the tensile test. Tests 1 and 25 show very plainly that the toughness cannot be entirely judged from the reduction of area or elongation; test bar 1 is the more ductile of the two but test bar 25 possesses greater notch toughness. Test 10 shows how far the tensile properties can come from indicating lack of toughness as the probable cause of failure, although the true character of the material is brought out by the notched-bar test. A comparison of the carbon steels with the special steels reveals a superiority for the latter that is not as clearly brought out by the tensile tests. The tensile tests indicate that the special steels have greater tensile strength for the same ductility but the superior toughness

of the latter is better brought out by the notched-bar test. The tensile properties of the cast-steel specimens show that cast steel may have excellent elongation and reduction of area, and be thus apparently ductile, but be quite lacking in resistance when tested in the notched condition. Thus cast steel behaves the same as a piece of over heated steel.

In Charpy's report of 1909, an interesting case was cited to show that the notched-bar test can give information regarding steel that is in no wise suggested by the tensile tests, either static or dynamic. The results obtained with two steels A and B, really the same steel in two

TABLE 2.—*Results Obtained by Notched-bar Tests*

Steel	Elastic Limit, Pounds per Square Inch	Tensile Strength, Pounds per Square Inch	Elongation, Per Cent.	Reduction of Area, Per Cent.	Static Resistance, Kilograms	Tensile Impact Resistance, Kilograms	Charpy Test, Kilograms
A.....	42,800	59,900	32.0	67.2	179.5	205	44.0
B.....	42,700	62,700	32.0	65.6	185.0	195	2.7

different conditions of heat treatment, are given in Table 2. Not even the resistance to fracture produced by a weight falling from a height of about 100 ft. (30 m.) as given in the next to the last column, indicates the excessive brittleness of steel B. The microstructure at once showed that B is in a much poorer condition than A.

These figures could be multiplied almost indefinitely and have been well known for over a decade. There can now no longer be any doubt that there is some property, which is of great technical importance, that is not measured and in many cases not even indicated by the usual tensile test. In spite of this undoubted fact, the Charpy test, which is now extensively used in Europe, is given but little attention in this country. This would seem to be due to lack of familiarity on the part of users of steel with the facts that in a very large number of cases materials are used in a notched condition, whether intentionally or otherwise, and that when so used the tensile test offers no reliable index of their probable behavior. If these points were considered, the purchaser would certainly insist that his materials show a high degree of notch toughness in all cases where they are to be used in the notched condition.

Various objections have been raised to the adoption of the notched-bar test, one of the principal ones being the so-called lack of uniformity of the results. This question has been gone into rather thoroughly by Prof. Howe,[17] and more recently by Charpy and Cornu-Thénard.[18]

[17] *Trans.* (1913) **47**, 501.

[18] G. Charpy and A. Cornu-Thénard: *Rev. de Mét.* (1917) **14**, 84; *Jnl.* Iron and Steel Inst. (1917, No. 2) 61.

In a number of cases the results of the notched-bar impact test are not as concordant as might be desired. It is the opinion of many experimenters, however, that variations in the impact resistance of supposedly similar test bars are due to actual variations in the material, the wide scale of the Charpy test throwing them into greater prominence than do the usual tests. The truth of this contention is demonstrated by the recent work of Charpy and Cornu-Thénard, who, by using exceptionally uniform and homogeneous bars, secured check results as close as 1 to 2 per cent. and scarcely ever varying as much as 4 per cent.[19] The results obtained by the commission of the German society were sufficiently concordant to lead to the adoption of the test and the minor variations were not permitted to mask the fact that the notched-bar test is capable of yielding valuable information that the tensile test does not.

The writer is informed that at least one steel plant, which has done considerable work on the notched-bar test including the Charpy test, has found the concordance of results to be very satisfactory and capable of yielding possible differences of impact resistance of the order of magnitude of 1:30. Thus, it would seem that lack of concordance can now no longer be advanced as an objection to the adoption of the Charpy test.

There has also been considerable objection to the presence of the notch in the test bar, the idea being that the nick localizes the breaking point and so does not test the weakest cross-section.[20] This is undoubtedly a point that must be considered when using the Charpy test. For example, if there is excessive segregation it is quite possible that the base of the notch will come at the weaker part and so lead to low results. At the same time such a variation in results is a valuable indication of segregation, so that by breaking a number of test bars not only can the average value be obtained but non-homogeneity in the material itself can be determined. The object of the Charpy test is not so much to test any particular test bar,[21] as it is to test the relative toughness of a certain material[22] or the efficacy of a certain heat

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[19] Even a 4 per cent. variation could scarcely be objected to on the score of lack of concordance in the light of the present practice in pulling test bars. A 4 per cent. variation would mean a variation from 49,000 to 51,000 lb. per sq. in., a variation that is much less than variations due to improper rate of loading, improperly holding the test bar in the machine, and in particular to the general neglect of the proportional limit in favor of the yield point as a measure of the elastic limit.

[20] H. M. Howe: The Resilience Test. *Met. & Chem. Eng.* (1917) **17**, **298**; Walter Rosenhain: "Introduction to the Study of Physical Metallurgy," 237. New York, 1915. D. Van Nostrand Co.

[21] The use of the Charpy test as an acceptance test would hardly merit discussion until the value and importance of the test proper is generally conceded.

[22] This statement is subject to the reservation advanced by Prof. Howe that, due to the greater plasticity of low-carbon steels, we cannot directly compare steels of essentially different carbon contents.

treatment. Moreover, it is quite customary, at least in certain quarters, to precede the Charpy test by macroscopic tests for gross segregations in order that variations due to such segregations may be eliminated.

Recently there has been an attempt to eliminate the notch from impact testing, in the impact shear test described by Dr. McAdam. In this test, an unnotched bar is sheared by an impact while the impact figure is read the same as in the Charpy test. It has been argued[23] that by eliminating all except one stress the impact shear test is superior to the Charpy test. There can be no doubt that materials to be subjected to shearing stresses by impact (in an unnotched condition) might well be tested by this method; but no test on unnotched bars can be substituted for a notched-bar test. The correctness of this assertion is supported by the results of the impact shear test according to which such materials as properly heat-treated nickel and chrome-nickel steels fail to give as much resistance to impact as carbon steel or even ingot iron.

Summary

Undoubtedly the occurrence of the notch effect in machines and engineering structures is much more common than is generally recognized. This is generally due to the design of the structure but may be caused by faulty workmanship. Even a hasty examination of such machines as locomotives, automobiles, stationary gas engines, steam engines, etc. reveals an amazingly large number of notches and in many such cases the material composing the parts should have a high degree of notch toughness to insure against failure.

The logical test for such materials and the only one capable of yielding reliable results is the notched-bar test. This test should supplement the usual tensile or hardness tests and its results used as an index of the resistance of the material to the notch effect.

A factor of safety is generally used in the design of parts of machines requiring the material to have a certain strength combined with a certain amount of ductility. These properties are written into the specifications and the material is inspected on such a basis. Neither the factor of safety nor the usual properties offer a guarantee against failure in cases similar to those discussed here. It is for this reason that the cause of many failures remains a mystery when test bars taken from the broken parts are found to pass all specifications. The Charpy test would undoubtedly show a low impact value, due either to faulty heat treatment, in case the parts were heat-treated, or to lack of proper heat treatment.

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[23] Personal communication.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Davidson Process of Casting Formed Tools

BY J. E. JOHNSON, JR., NEW YORK, N. Y.

(New York Meeting, February, 1919)

THE production of metal-working tools has been revolutionized within the last 18 years, since the invention by Taylor and White of a process of heat-treating steel tools, which resulted in increasing their cutting capacity several fold over what it had been before. This was an exceedingly important invention, although it consisted principally in establishing this fact: overheating when it accidentally occurred in the ordinary process of forging, spoiled the steel, but if carried very much farther or to a point that would have been considered absolutely ruinous to the steel under the old ideas, it resulted in imparting a cutting power several times as high as had ever been obtainable before.

The quality that gives the steel this power eventually received the name of "red hardness." This name originated in the fact that tools possessing this property retain their resistance to deformation even when subjected to such severe cutting stresses that the metal just back of the point is heated, under certain conditions, to a visible red. It is interesting in this connection to note that the edge of the tool itself does not become red because it is continually cooled by the fresh metal into which it is forced.

The result of Taylor and White's invention was an intensive study of tool steels all over the world and, although there was great diversity of analysis in the high-speed steels of the early days, these steels today generally have an approximately similar composition, the principal constituents being from 15 to 20 per cent. of tungsten, from 4 to 6 per cent. of chromium, from 1 to 2 per cent. of vanadium, and from 0.50 to 1 per cent. of carbon. It is probably safe to say that standard brands of such high-speed steels will do from five to ten times as much work in a given time as the carbon steels, and even the Mushet steels, which were the sole dependence up to the beginning of this century, when the Taylor-White process was discovered. With the increasing cost of labor, it is not surprising that these steels have driven from the market, for all but limited purposes, the older types of steel.

These types of steel are harder and more difficult to work than ordinary carbon steel. It was for several years considered impossible to weld them at all and, while this can be done now, it is not a process that commends

itself to the best toolmakers. For the ordinary run of tools made from straight bars, such as those used for lathes, planers, and shapers, the processes of manufacture have not been much more difficult and expensive than the same processes for the older tools, the steel being cast into small ingots and then rolled or hammered to bars of the desired section, from which the desired form of tool is produced by forging and grinding a cutting edge on one end. For formed tools, such as milling cutters, large drills, countersinks and other shapes that do not lend themselves to production from the straight bar, the conditions are very different from those obtaining when old-fashioned carbon steel is used.

The production of a milling cutter or similar formed tool by existing methods is an expensive operation. First a blank of suitable size must be produced by forging an ingot, or large bar, and if the cutter is at all large, a bar of extra large size must be produced in order to make it. After forging, the rough blank is annealed and then sent to the tool room for machining. This must be done with great care and accuracy, and usually involves a multiplicity of operations, since the formation of each tooth involves several cuts. The labor that does this work is deservedly the highest priced mechanical labor we have today, and its output is necessarily limited for the reason that after forging, which is a rough operation, much stock must be taken off in the production of formed cutters.

The production of formed tools of high-speed steel by these methods involves a much greater cost than the production of similar tools of carbon steel for two reasons:

First, the expensive alloys, tungsten, chromium and vanadium, that must be liberally used for good high-speed steel, make the cost of the cast metal, irrespective of its form, many times more expensive than carbon steel (about 20 times in recent years). Forging is a rough operation, and in the production of formed tools, much of the forged blank must be cut to waste, but if the number of pounds is the same in both cases, the loss in dollars and cents is greater with the high-speed steel almost in proportion to its higher price.

Second, more of the expensive labor required for this work must be consumed in the production of formed tools of high-speed steel than of carbon steel because the greater hardness of the former, even in the annealed condition, is necessarily reflected in slower machining.

At different times in the last 2 or 3 years, various people have conceived the idea of casting tools to shape and some progress has been made in this art. It is understood that one large manufacturer has such a process in more or less regular commercial use. There are three difficulties with this process, from the point of view of ordinary steel melting practice: (1) That of getting the steel killed so dead that it will be free of blow-holes as cast. (2) That of producing a metal fluid enough

to flow into the fine parts of the mold and give sharp true castings. If this cannot be done, only the rough cuts in machining the cutters are saved and the difficulty involved in cutting the scale may easily offset this gain. (3) That of producing a satisfactory structure to give great endurance and long life to the steel without the refining of the grain which is often considered to come only from the forging operation.

A year or two ago some tools made by a direct casting process came into the hands of A. C. Davidson. It was soon ascertained that, for the reasons just stated, they could not compete with the older type of tools either in quality or price. Mr. Davidson had previously found that it was possible to kill steel much more completely than had hitherto been possible. He had also had a wide experience in the production of steels for different purposes and in their heat treatment. He believed that by the application of his process of killing the steel and his knowledge of heat treatment he could eliminate the defects in cast tools. He therefore began a long series of experiments for that purpose.

In April, 1918, the writer was retained to supervise a test of the process and see whether the claims made for it could be substantiated. Mr. Davidson had at that time no works of his own and it was necessary to hire a crucible furnace, which had at one time been used for making crucible castings but which had been out of use for some months. This furnace was of poor design and in a bad state of repair, but it was thought that it would serve for a demonstration heat. Ten 100-lb. crucibles were accordingly charged under the inspection of the writer and put into the furnace. One of these was charged entirely with high-speed steel scrap, largely that resulting from previous melts made by Mr. Davidson. This was done with the object of proving whether or not the gates and risers resulting from the casting operation could be worked up in subsequent heats, since the losses that would result would destroy the value of the process if these had to be thrown away.

The furnace worked so badly that the heat instead of coming out in 6 hr., as it should, was in the furnace about 9 to 10 hr. and only three pots became hot enough to pour at all, the metal even from these being entirely too dull for the best results. After this number had been poured, the cover over the furnace flue collapsed and the heat had to be terminated. The conditions surrounding the test were therefore in every way unfavorable and disadvantageous. Nevertheless a number of milling cutters, countersinks for ship rivets, and forming tools were cast, some of the best of them coming from the pot charged entirely with scrap. Two of the cutters and one of the countersinks were taken from the works by the writer, etched with private identification marks, turned back to Mr. Davidson for annealing, machining, hardening, and grinding and were then returned by him to the writer for test. In order to have a fair standard of comparison, a Brown & Sharpe side milling

cutter of one of the best brands of high-speed steel was bought directly from the works. The tests were made at the Quintard Iron Works through the courtesy of the owners and with the coöperation of the superintendent, Mr. Wittman. The 6-in. by ¾-in. (152.4-mm. by 19.05-mm.) milling cutter contained a number of steam holes caused by wet molds. It was by no means a perfect casting, nevertheless it stood up favorably against the Brown & Sharpe cutter under the most extreme test that could be given it.

A 2½-in. by ½-in. side milling cutter was then put in the machine and tested at gradually increasing speeds until finally the limit of the machine was reached. The cutter was taking a depth cut like a key-seat in a bar of steel of 0.30 or 0.40 per cent. carbon, this cut being the width of the cutter by ¼ in. (6.35 mm.) deep. On the final test, the cutter was run at a speed of 400 revolutions per minute, with a feed of 7 in. (177.8 mm.) per min. This is a linear speed of about 250 ft. (76.2 m.) per min. and, as stated, was the limit of the machine. The cut was run as far as the clamps on the test bar would permit, and as it was not possible to test the cutter any more severely, the test was stopped and the cutter taken out. It has been preserved and will be shown at the meeting. As far as I can see it shows no sign of the gruelling test to which it was subjected.

The countersink for ship rivets was turned over to Mr. Milne, the general manager of the Todd Shipbuilding Co., with the request that he give it a thorough tryout in comparison with the best countersinks obtainable in the market. No quantitative tests were made at this plant but Mr. Milne reported that the countersink compared most favorably with any others that could be obtained.

In spite of the fact that the casting conditions were so bad, the results of the test seemed to indicate the probability that tools could be produced by this process free from blow-holes and sufficiently true to form to be finished merely by grinding the cutting edges.

The structure of the steel appeared to be so good and the tests were so satisfactory that Mr. Davidson was advised to proceed with the commercial development of the process. A small foundry was obtained in Brooklyn, a crucible furnace built, molding machines, etc. installed, as well as machine tools for finishing or partially finishing the product. Production was started in August and has proceeded regularly ever since. At the present time the business has developed so that an electric furnace is being put in for melting the steel which it is expected will be in operation by the time this paper is published.

Many tests have been made of these cast tools against the best of the forged machined tools obtainable in the market, and in practically every instance the cast tools have proved superior to the machined ones, sometimes by a very large margin.

Various tools in different stages of completion will be shown at the meeting, which illustrate the work that is done and the character of the steel far better than it can be described in words. It will be noted that milling cutters are cast with a projecting lip on the cutting edge; this is finished entirely by grinding and with little more expense than the grinding of a machined tool. A perfect edge is obtained in this way with a minimum of labor and lost steel, while the possibility of local defects is avoided.

The material used for killing is a secret of which the writer has no knowledge; it may be said, however, that the results are striking in the last degree.

The notable features are three: First, the extraordinary freedom from blow-holes; second, the fluidity of the metal; and third, the entire absence of coarse crystallization in the casting.

In regard to the first of these features, it may be stated that the foundry ran for several weeks before the completion of its baking oven, pouring the steel largely into green-sand molds, and yet made satisfactory tools, their being only a few steam holes near the surface. Since the drying oven was put into operation, blow-holes of any description are practically unknown.

In regard to the second, the metal, instead of having a comparatively ropey pour, is thin and fluid more like good hot cast iron than like steel. As a result the details of small cutters are cast practically perfect, as shown. These results are not picked samples but represent the general run of the work done.

In regard to the third feature, it is well known that most steel, when cast, has a coarsely crystalline or fiery structure, but an examination of the fresh fractures of this steel shows that this is almost wholly absent; in fact, the structure of this steel, as cast, looks more like that of forged steel than it does like a casting.

For the benefit of the scientifically inclined, photomicrographs are here presented, which were prepared by Sauveur & Boylston of Cambridge, Mass. These reveal the microstructure of a first-class make of forged and machined high-speed steel cutter and of a Davidson tool. With these are submitted a statement prepared at my request by H. M. Boylston, of the above firm, which is as follows:

Davidson Tool Manufacturing Co., D. T. M. Cutter.—This was a piece about ¾ in. (19.05 mm.) in section, showing a scale on all sides but one, which had evidently been cut. We prepared the cut surface and photomicrographs, Figs. 1 and 2, represent the structure respectively at 100 and 400 diameters. It will be seen that the structure is fairly fine for a casting and consists of a light matrix in which some polyhedral networks can be indistinctly seen, Fig. 2. Embedded in this matrix are three other constituents; one a dark mottled constituent resembling

troosto-sorbite in ordinary carbon steel and resembling also the dark constituent in a cast high-speed steel of ordinary composition or of an ordinary high-speed steel after forging and annealing. The second constituent is a light hard one forming a herring-bone design and is plainly a eutectic of some sort. It is similar in quality but greater in quantity

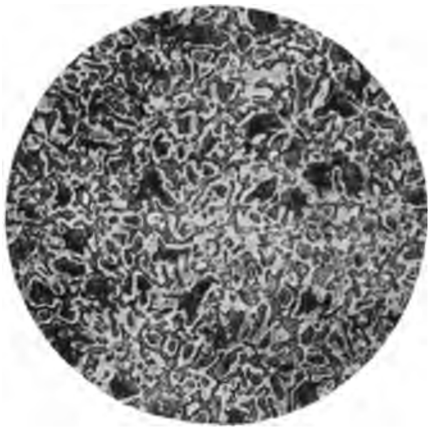

FIG. 1.—SECTION OF D. T. M. CUTTER FROM THE DAVIDSON TOOL MANUFACTURING CO., ETCHED IN 5 PER CENT. NITAL SOLUTION FOR 30 SEC. × 100.

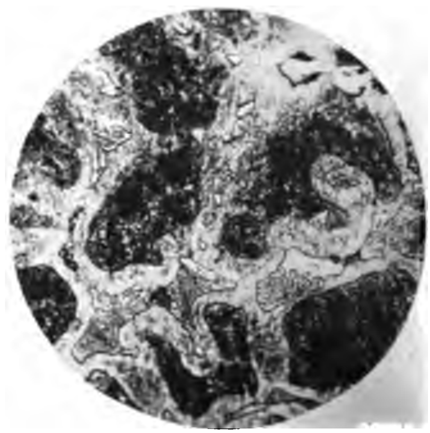

FIG. 2.—SECTION OF D. T. M. CUTTER FROM THE DAVIDSON TOOL MANUFACTURING CO., ETCHED IN 5 PER CENT. NITAL SOLUTION FOR 30 SEC. × 400.

FIG. 2*a*.—SECTION OF TOOTH FROM A DAVIDSON TOOL MANUFACTURING CO. MILLING CUTTER, ETCHED IN 5 PER CENT. NITAL SOLUTION FOR 7 MIN. × 400.

to the so-called carbide envelopes found in ordinary cast high-speed steel. The fourth constituent consists of a series of separate small rounded hard white spots similar to the excess carbide found in an ordinary high-speed steel both before and after hardening, provided the sum of the carbon, tungsten, and chromium contents are high enough. The structure of this sample is more like that of an ordinary high-speed

steel casting than that of a well-treated high-speed steel after forging, annealing, and heat treatment, but it is also clearly different from the structure of an ordinary high-speed steel casting of good quality, in that the dark constituent of a sorbitic appearance is much less in quantity than in an ordinary high-speed steel casting, while the herring-bone eutectic is larger in quantity than is found in the carbide envelopes of an ordinary high-speed steel casting. The ordinary casting, also, does not contain the separate bright white constituents seen in the D. T. M. tool, while the D. T. M. tool apparently has some austenite (the polyhedral grains dimly seen in places in Fig. 2).

Photomicrographs of an ordinary commercial high-speed steel casting (from an ingot) magnified 100 and 400 diameters respectively are given for comparison in Figs. 3 and 4.

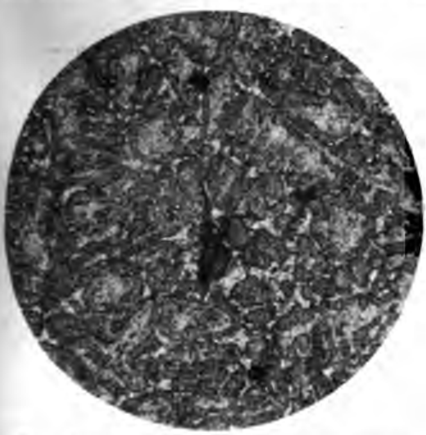

FIG. 3.—SECTION OF CAST HIGH-SPEED STEEL, ETCHED IN 4 PER CENT. NITAL SOLUTION FOR 30 SEC. × 100.

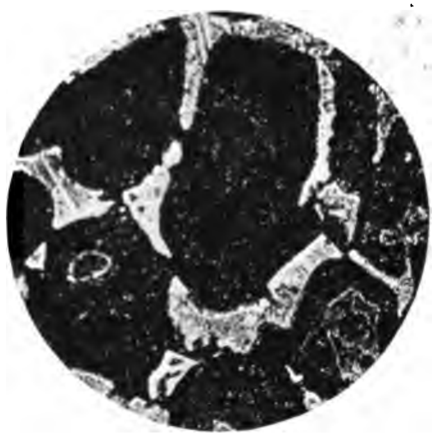

FIG. 4.—SECTION OF CAST HIGH-SPEED STEEL, ETCHED IN 5 PER CENT. NITAL SOLUTION FOR 30 SEC. × 400.

Commercial Milling Cutter.—The structure of the commercial milling cutter submitted to us is that of a commercial high-speed steel with an unusually large amount of free carbide forming almost complete envelopes in some cases. The background is austenite with some fine markings, which we judge to be due to the tempering process. The structure as a whole is very different from that of the D. T. M. cutter but is characteristic of an ordinary high-speed steel forged cutter that has been heat treated and tempered. There is a dark constituent surrounding the free carbide areas in this sample, which would seem to indicate that the heating for hardening has either been too low or has been continued for too short a time, so that the annealed structure is not entirely obliterated. The fact that the networks of austenite are often incomplete and the large amount of free carbide present are additional evidence of this defective heat treatment. While we have called

this defective heat treatment, it may not be a very serious matter in a cutter of this size, although we should look for brittleness at the edges of the cutting teeth which are on the periphery of the cutter.

The photographs are magnified 100 and 400 diameters respectively, and marked Figs. 5 and 6.

We are not prepared to make any statement in regard to the probable cutting properties of the D. T. M. fragment as compared with the Brown & Sharpe cutter, since it would take actual cutting tests to determine this.

Fig. 5.—Section of a Brown & Sharpe milling cutter, etched in 5 per cent. nital solution for 7 min. × 100.

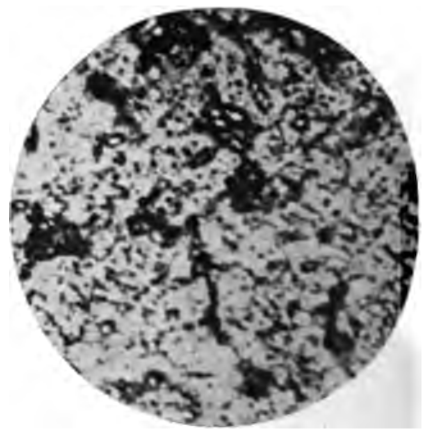

Fig. 6.—Section of a Brown & Sharpe milling cutter, etched in 5 per cent. nital solution for 7 min. × 400.

Since the feathery constituent mentioned by Mr. Boylston, and shown in the photomicrographs of the Davidson tool, appears from Mr. Boylston's statement to be rather rare and is abundant in this steel, I am led to think that the surprising quality of these tools may be due, in some degree, to the presence of this constituent. It seems well to point out here, however, that the metallography of cutting tools is not sufficiently developed to enable us to say, even from a good photomicrograph, that a certain tool is definitely good or bad. The science will undoubtedly reach a state of development where this will be possible, but for the present the only safe gage of the quality of high-speed steel tools is a test under working conditions, the test to be continued to destruction if possible. Judging from the number of cases in which the cast tools have outstripped all others in such tests, a suggestion not unworthy of consideration is that the structure shown by the Davidson tools is that at which other toolmakers should aim.

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Prevention of Columnar Crystallization by Rotation During Solidification

BY HENRY M. HOWE,* LL.D., SC.D., AND E. C. GROESBECK,† S.B., M.A., BEDFORD HILLS, N. Y.

(New York Meeting, February, 1919)

(A Contribution from Green Peace Laboratory)

THAT the quiescence of a liquid while it is solidifying should favor the formation of columnar crystals, normal of the cooling surface, is seen readily on considering the mechanism of solidification.

First, each particle of any composite liquid, whether it be an aqueous solution or a molten metal, in solidifying splits up into two parts, different in composition and hence in fusibility. One part is infusible at the existing temperature, and hence solidifies, and in general attaches itself to the inclosing walls of metal which have already solidified; A, Fig. 1. The other part is fusible at the existing temperature and hence remains molten. In the case of carbon steel, the part of each drop which actually solidifies is poorer in carbon than the drop itself was before it began to solidify, and this impoverishment of the solidifying half-drop enriches the other half-drop in carbon, and thus makes it unfreezable at the existing temperature.

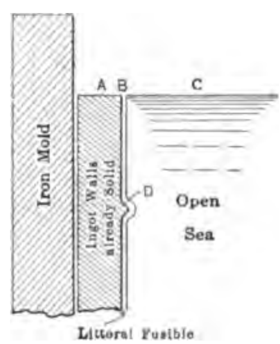

FIG. 1.—MECHANISM OF SOLIDIFICATION.

By this mechanism there arises during solidification a "littoral" or shore layer of liquid, B, Fig. 1, bathing the already solidified walls, and more fusible than either those walls or the great remaining central mass of liquid or "deep sea," C, from which it separates them. It is essential that we grasp clearly this conception of a fusible littoral molten layer coating the already solidified walls and separating them from the deep sea.

Meanwhile heat is flowing rapidly outward through these walls, its escape cooling them, so that if any given particle of the deep sea metal

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could get past this littoral layer and come into contact with the solid walls, it would in turn solidify, and like its predecessors would split up in solidifying into a less fusible half-drop which would attach itself to those walls and a more fusible one which would remain molten. Thus we see that solidification can be continued only by some process of diffusion or convection, which will bring the freezable, because less fusible, deep sea metal past this fusible envelope which coats the solid walls, and into contact with them.

And this brings us to the columnar mode of crystallizing. Any projection, such as D, from the face of the walls will be reached earlier than the adjoining smooth unprojecting parts by the freezable deep sea particles. Further, each such projection increases its advantage over the neighboring smooth faces with every fresh addition to its tip. More-

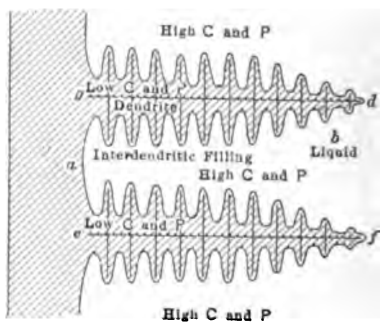

FIG. 2.—CONCENTRATION OF CARBON AND PHOSPHORUS IN THE FILLING BETWEEN ADJOINING COLUMNAR CRYSTALS.

over, this increment of advantage is continuous, and indeed continuously self-exaggerating. Growth at the tips of these projections in itself is the columnar growth.

This sketch of the growth has been somewhat simplified by dwelling on convection as leading freezable droplets past the fusible and unfreezable littoral layer of the molten mass. But what we have sketched as true of convection should be true of diffusion, which is probably more effective than convection in feeding the tips of the protruding crystals.

Having come thus far, we take the next step of recognizing that agitation, in that it tends to bring fresh freezable metal from the deep sea to the sides also of the growing crystals, thus diminishes the advantage which the tips have over the sides, and thus diminishes the columnarity of the growth. In particular, if we can keep the molten metal constantly sweeping past our supposed projections, it will in the first place sweep away the fusible littoral layer, and in the second place bring fresh freezable deep sea metal to the sides as well as to the ends of the columns.

The harmfulness of the columnar structure, especially if the columns themselves are coarse, is seen by considering a later stage of this growth,

as sketched in Fig. 2. In the case of steel ingots, the splitting up which accompanied the solidification of each droplet rejects not only carbon but also phosphorus into the littoral layer. If the parts of this which wash the sides of the columns are well landlocked, as in Fig. 2, this local concentration of the littoral layer in these elements will continue, and will progressively exaggerate itself as solidification progresses, leading at last to a marked local enrichment or segregation of these and other elements in the part midway between each pair of neighboring crystals. This

FIG. 3.—UPPER SURFACE OF ROTATED INGOT, SHOWING STRONG SPIRAL MARKINGS. × 1.

is very harmful, because this segregate forms a brittle link in the chain, where rupture may occur under a shock which would fail to break the metal if it were uniformly distributed.

Continuously varying rotation during solidification should evidently be a very effective way of keeping the molten metal sweeping past the growing walls. This was proposed by Tchernoff[1] before 1880, and was carried out by Webb.[2] Tchernoff pointed out that the rate of rotation for this purpose should be as great as possible at first and that its direction should be changed rapidly and violently.

Webb[2] cast locomotive driving wheels thus, feeding the mold in the center, while rotating it slowly at first, accelerating the rotation to about

[1] D. K. Tchernoff: Structure des Lingots Coulés en Acier. *Rev. Universelle* (1880) [2] 7, 154.

[2] *Jnl.* Iron and Steel Inst. (No. 2, 1882), 522.

40 to 50 revolutions per minute when the mold was filled, and then reducing the speed gradually. These two inventors almost certainly intended to prevent columnar crystallization by this means, though the mechanism of solidification was not known then. Our experiments carry out their forgotten and re-invented process.

In order to cause the continuous variation of rate of rotation, we set the vessel in which solidification is to occur on the horizontal disk of a common polishing machine, such as is used for preparing sections for microscopic examination. By holding the belt which drives this disk in the hands one can readily bring about a very rapid and continuous variation in the rate of rotation, by starting the rotation slowly to the

FIG. 4. FIG. 5.
FIG. 4.—STATIONARY INGOT. × 1. FIG. 5.—ROTATED INGOT. × 1.
ABOUT HALF OF THE ETCHED VERTICAL SECTION OF EACH INGOT IS SHOWN HERE.

right, clockwise, bringing it rapidly to a maximum and again retarding it and replacing it with contra-clockwise rotation. In order to show clearly the effects of this rotation, two like lots of the liquid or molten mass in each experiment were poured in immediate succession and in like manner into two like vessels, one of which was allowed to cool undisturbed while the other was rotated as just described. For brevity this method may be referred to as simply "rotation," which in every case varied continuously.

Experimental Results.—A strong hot solution of ammonia alum gave very much coarser crystals with quiescent solidification than with rotating solidification. Like results were reached with commercial zinc.

In order to introduce still greater differentation during solidifying, we next tried a mixture of zinc with about 5 per cent. of type metal,

under the following conditions. The metal was melted in a clay crucible under charcoal, was thoroughly stirred, and was then poured half into a stationary iron mold and half into a like mold standing on the polishing disk, and rotating reversingly during pouring and for a long time after the upper crust had solidified. The conditions were as follows:

	Min.	Sec.
Poured into stationary mold at	0	0
Poured into rotating mold at	0	15
The upper surface of ingot in the rotating mold was completely frozen over at	6	55
The rotation was continued till	36	35

The strong spiral markings on the upper surface of the rotating ingot are seen in Fig. 3. Note how much more marked the columnar crystals are in the stationary Fig. 4, than in the rotated one, Fig. 5.

Fig. 6.—Furrows in walls of pipe in stationary ingot. × 1.6.

In every case in which the rotation was continued for a long time, results like these were reached. In one case in which the rotation was stopped soon after the upper surface had frozen over, no very marked difference between the stationary and rotated ingot appeared. This, we believe, was because most of the solidification occurred after the rotation ceased.

Fig. 6 shows the marked furrows in the central pipe, to the occurrence of which in steel one of us has already called attention.[3]

[3] H. M. Howe: *Trans.* (1907) **38**, 3-108.

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Producotin of Ferromanganese in the Blast Furnace*

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(New York Meeting, February, 1919)

Introduction

SOMETHING of a mystery has attached itself to the production of ferromanganese in the blast furnace. This alloy has been produced on the Continent almost continuously since 1876 and in very considerable tonnages, but little definite information concerning the practice is to be found in technical literature, and almost nothing in the way of a theory of the manganese furnace. In this country prior to 1904, but one company had attempted its production in a serious way, and none of the operating data or other information from this company has been, or is, available to the public.

In the last 5 years, as a result of the restriction of imports, a number of furnaces have been blown in on this alloy, with the result that in 1918 as many as 18 furnaces were in blast. The majority of the men in charge of these furnaces had had little previous experience in such operations. Realizing the advantages both to the country and to the industry from a pooling of operating data and experiences, the Bureau of Mines, in the summer of 1918, undertook the collection of data from ferromanganese furnaces. Although the results of this investigation have already been reported to the companies coöperating, they may be of permanent metallurgical interest, so this paper attempts to give, briefly, the more important points brought out in the investigations.

Operating Data in Ferromanganese Practice

Operating data were collected by the Bureau from 11 ferromanganese furnaces, which will be referred to throughout this paper as furnaces A, B, C, F, G, I, J, K, L, M, and P. The dimensions of seven of the furnaces are given in Table 1. The companies from whom this infor-

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† Assistant Physicist, U. S. Bureau of Mines.

mation was obtained and to whom should go the credit for whatever value this information may possess, are the Bethlehem Steel Co., B. & B. Trading Co., Buffalo Union Furnace Co., Donner Steel Co., John B. Guernsey & Co. Inc., E. E. Marshall, Miami Metals Co., Seaboard Steel & Manganese Corpn., Southeastern Iron Corpn., and the Wharton Steel Co.

TABLE 1.—*Dimensions of Ferromanganese Furnaces Investigated*

Furnace	Height, Stock Line to Center Line of Tuyeres, Feet	Bosh Diameter, Feet	Hearth Diameter, Feet
A	62.1	13.4	8.8
B	55.0	16.5	9.5
C	66.2	14.8	9.5
F	57.8	15.2	10.5
G	63.0	18.0	11.5
J	67.4	18.3	13.0
K	63.0	18.6	13.2

The essential operating data are given in Table 2, presented in the form of 40 "runs" or experimental periods, each run being the average figures for 10 days continuous operation. It was intended, in selecting the 10-day periods, to cover as wide a range of operating conditions as possible, with due regard for the steadiness and constancy of the operation during the period. More accurate data would have been obtained from averages covering several months. It must be remembered, however, that averages taken over long periods suppress most of the variations in practice from which it was hoped to obtain information.

In addition to the figures taken from the furnace records, samples of downcomer gas were taken by the Bureau at five furnaces, these samples being analyzed for O_2, CO_2, and CO. At six furnaces, supplementary temperature measurements were taken with Leeds & Northrup pyrometers. These measurements were made with the pyrometer sighted: down a tuyere, with and without a tuyere glass interposed; on the surface of the slag at flush and at cast; and on the surface of the metal at cast. When the apparent temperatures are corrected, in the case of tuyere temperatures for the absorption of the glass screen when present, and in the case of the slag and metal for their respective emissivities,[1] a fair idea of the temperatures existing in the combustion zone, in the slag bath and in the metal bath of the furnace should be given. Since most of the data in Table 2 concerns furnace operation carried out before the visit of the Bureau's field party, it is doubtful whether the gas

[1] The emissivity corrections used are those given by Burgess.

Experiment	Furnace	Ore, Lb. per Ton	Coke, Lb. per Ton	Coal, Lb. per Ton	Stone, Lb. per Ton	Ore Analysis			Tons per Day	Slag, Lb. per Ton	Metal, Per Cent. Mn	Metal, Per Cent. Si	Blast Temp., Deg. F.	Top Temp., Deg. F.	Cu. Ft., Per Min.	Slag Analysis					Carbon, Lb.	Mn Charged, Lb.	Per Cent. to Metal	Per Cent. to Slag	Per Cent. Lost in Stack
						Mn, Per Cent.	Fe, Per Cent.	SiO_2, Per Cent.								CaO, Per Cent.	MgO, Per Cent.	Al_2O_3, Per Cent.	SiO_2, Per Cent.	Mn, Per Cent.					
1	A	5981	4658	...	1980	41.18	4.54	7.78	45.7	2671	78.2	0.76	1308	935	12,870	27.2	9.7	13.0	27.8	14.6	3810	2462	71.2	15.8	12.9
2	A	5303	5475	...	1780	39.11	6.65	5.64	37.2	2445	70.6	1.47	1268	1025	12,820	24.1	8.9	16.2	28.2	15.6	4440	2075	76.4	18.4	5.2
3	A	5870	6290	...	1820	39.43	7.42	6.33	29.0	2805	71.3	0.92	1196	1049	......	23.9	8.6	16.2	26.3	18.9	5360	2316	69.0	22.9	8.1
4	A	6000	7133	...	2320	42.01	3.33	8.45	33.3	3035	80.9	1.24	1232	1054	......	30.1	10.3	13.2	29.8	11.7	5820	2520	72.0	14.0	14.0
5	A	5090	5016	...	1632	42.25	6.07	6.73	35.7	2248	73.5	1.24	1432	998	12,510	26.5	9.6	13.5	28.7	14.9	4060	2149	76.3	15.5	8.0
6	A	5475	5628	...	1806	39.80	11.28	4.34	40.9	2180	69.4	0.73	1279	1147	......	30.1	10.9	17.0	27.4	9.4	4560	2180	71.2	9.5	19.3
7	A	5720	5595	...	1860	38.45	14.95	2.58	41.5	2070	68.3	0.85	1303	1103	......	33.1	11.5	15.4	28.3	9.4	4480	2200	71.0	9.4	19.6
8	A	6166	7352	...	2172	36.66	4.60	6.14	29.5	3335	78.3	0.70	1175	1014	......	38.2	11.8	14.1	25.5	6.9	5992	2260	77.8	10.1	12.0
9	A	6990	7836	...	2112	37.14	3.69	6.65	31.2	3460	80.35	1.86	1150	979	......	....	....	15.7	26.2	5.3	6380	2600	66.8	7.0	23.7
10	B	7560	8070	...	2700	35.75	6.35	15.06	33.8	4630	72.34	0.62	786	.....	......	....	....	11.1	29.9	13.6	7080	2700	60.0	22.5	17.5
11	B	6212	7776	...	2180	36.70	4.41	17.05	35.0	4110	77.13	0.58	770	.....	......	....	....	12.5	28.7	9.5	6810	2280	75.8	17.1	7.1
12	B	7545	8435	...	2475	36.00	6.14	14.97	33.8	4460	72.88	0.74	886	.....	......	....	....	11.0	30.5	13.3	7400	2715	60.1	21.9	18.0
13	B	6025	7534	...	2265	38.00	3.43	15.28	34.7	3670	77.7	1.43	782	.....	......	44.3	....	14.1	29.8	9.1	6600	2292	76.0	14.6	9.4
14	B	8102	9510	...	3320	34.00	7.75	17.84	35.0	5745	74.5	0.58	830	.....	......	35.5	....	10.7	31.3	15.6	8340	2760	60.6	32.4	7.0
15	F	7099	7539	...	3168	42.91	4.09	11.30	32.0	4100	76.3	0.37	735	757	14,380	28.4	6.5	11.1	29.1	19.8	6220	3045	56.1	25.6	18.3
16	F	4813	6092	...	2091	43.68	6.71	6.87	44.9	2470	79.1	0.83	993	328	22,500	35.0	9.9	10.3	27.5	13.2	5030	2108	84.4	15.5	0.1
17	F	4831	6431	...	2084	45.76	5.90	8.44	44.7	2610	78.8	1.12	1027	143	22,500	33.3	11.2	11.5	27.8	11.3	5310	2218	80.2	13.3	6.5
18	G	7525	5460	546	2941	32.53	5.60	12.62	56.5	4600	78.2	1.53	1140	730	17,500	25.2	10.7	13.9	29.8	11.3	5140	2450	71.5	24.9	3.6
19	G	6050	4863	459	2675	32.52	5.60	12.62	60.7	3765	67.5	1.61	1183	780	16,900	26.2	12.8	15.2	30.9	11.4	4565	1969	77.0	21.8	1.2
20	I	8150	7282	...	3160	39.26	2.40	15.54	50.0	5040?	71.4	1.92	952	1016	17,100	26.6	14.1	11.3	27.7	11.4	5990	3200	52.7	18.0	29.3
21	I	5850	4652	...	2165	41.64	5.54	7.43	82.7	2555	77.1	0.56	1277	934	16,500	31.4	12.6	11.4	26.5	12.0	3825	2435	71.0	12.6	16.4
22	J	8560	6940	...	2510	34.83	4.00?	14.92	60.8	6230	69.1	2.05	1108	849	20,000	24.2	11.1	13.8	30.4	15.1	5550	2935	51.6	31.2	17.2
23	J	5040	500	432	1278	44.73	4.06	2.60	94.1	2050	79.2	0.75	1156	496	19,500	26.0	8.9	24.2	21.7	8.1	4395	2258	78.7	7.4	13.9
24	J	4900	2900	415	1264	45.20	3.80	2.53	70.0	2020	79.7	0.63	1237	.....	20,000	27.3	7.1	23.5	21.3	13.3	4340	2226	80.3	12.1	7.6
25	J	4960	4955	419	1255	43.75	4.18	2.86	97.9	1985	79.3	0.61	1172	562	19,500	27.9	7.1	24.5	20.9	12.1	4434	2168	81.6	11.1	7.3
26	K	4040	6275	...	1985	50.65	7.27	6.52	46.9	2190	75.9	2.43	950?	.....	......	46.4	1.7	14.7	27.3	5.4	5420	2048	83.0	5.8	11.2
27	K	4480	5802	...	2268	51.13	7.10	5.35	85.8	2580	74.8	0.29	970	965	17,500	37.1	1.1	11.4	28.8	14.3	4690	2288	73.1	16.2	10.7
28	K	4650	6368	...	2184	50.11	7.30	5.57	49.5	2315	75.9	1.82	950?	.....	......	46.6	1.5	13.8	27.6	5.7	5450	2330	73.0	5.7	21.3
29	K	5215	6329	...	2386	46.94	10.80	6.24	77.5	3235	62.5	0.26	998	845	19,100	33.3	1.4	11.1	26.5	19.6	5280	2442	57.2	26.3	16.5
30	L	6770	7458	660	2965	39.97	3.51	7.53	48.1	3126	80.7	1.29	1065	1162	17,800	40.3	6.8	11.7	31.1	8.8	6730	2710	66.9	10.3	22.8
31	L	6565	8459	747	3100	39.68	3.69	7.40	43.0	3305	81.1	1.47	1043	1152	17,700	47.7	5.7	12.8	27.4	4.6	7655	2608	69.7	5.9	24.4
32	L	5312	6500	524	2582	35.45	9.54	8.91	64.7	2886	69.8	0.75	1089	1162	18,800	42.0	5.6	11.8	29.9	7.2	5951	1888	82.8	10.1	7.1
33	L	6222	6421	424	2528	35.38	4.50	6.28	50.5	2727	78.4	2.72	1204	1127	17,800	43.3	4.3	14.5	27.3	6.9	5651	2200	79.7	11.1	9.2
34	L	5465	4855	471	2200	32.38	8.02	10.11	77.2	2452	70.4	1.46	1457	1123	18,800	41.9	6.3	10.5	31.6	5.8	4432	1770	89.0	8.1	2.9
35	L	5200	5164	352	2155	33.53	7.81	8.63	77.1	2256	71.8	2.23	1207	1140	18,800	44.3	4.9	13.2	31.0	4.4	4538	1745	92.1	8.7	-0.8
36	P	7000	5350	545	3591	38.70	4.25	15.89	61.3	4468	78.1	....	1450?	750?	......	41.0	....	14.9	35.4	4.5	5060	2718	64.5	6.4	29.1
37	P	4117	4965	503	1680	45.50	5.55	4.85	78.0	1880	80.9	....	1450?	750?	......	45.6	....	18.8	20.3	9.9	4700	2060	83.0	4.9	7.1
38	C	5245	5704	811	2773	40.70	7.45	7.01	35.0	2700	74.9	2.19	1387	952	......	29.8	18.2	10.7	32.2	7.3	5280	2138	78.7	8.9	12.3
39	M	6586	7118	998	3042	45.11	3.66	6.59	42.0	3900	75.7	1.20	1242	905	......	38.8	....	14.4	25.7	15.2	6500	2970	57.1	20.0	22.9
40	M	6598	7100	957	3510	46.36	4.15	4.08	36.8	3480	74.5	1.30	1182	910	......	43.3	....	11.1	28.7	11.8	6471	3056	54.5	13.4	32.1
Average.		5992	6326	200	2349	40.33	5.93	8.60	51.7	3196	74.9	1.15	1135	690	......	Bases 41.75	..	14.0	28.1	10.6	5323	2382	72.0	14.7	12.8

analyses and temperature measurements taken by the Bureau are strictly applicable to the average practice indicated in Table 2, but no better figures being available, these must serve.

Average Practice for Ferromanganese Furnace and for Iron Furnace

Probably the most satisfactory method of discussing the ferromanganese furnace will be by comparing its figures to those of the iron furnace. A number of excellent descriptions of iron-furnace operation have been published, but it is doubtful whether a closer approximation has been made of the general practice obtaining in the larger modern iron furnaces than the following average figures collected by the Bureau from nine of the largest plants in the country. No measurements of slag, metal, or combustion-zone temperatures on these furnaces were taken. The average of the measurements by Linville,[2] Johnson,[3] and Feild[4] and unpublished measurements made by the Bureau at some eight iron furnaces are taken as the nearest approach to an estimation of these temperatures. A comparison of the more important figures for the two practices is given in Table 3. The important differences noticeable in this comparison are that the ferromanganese furnace received about three times as much coke and over twice as much stone as the iron furnace, lost over five times as much carbon by CO_2 absorption, operated with a hotter top and a colder combustion zone, produced colder metal and slag, and produced gas with a CO/CO_2 ratio two and a half times as great. The points of similarity are that the blast temperatures were roughly the same, and the slag compositions were essentially the same if the dilution of the ferromanganese slag with MnO is ignored.

These points of difference and of similarity are due to the operation of the furnace. In addition, there are differences due to the nature of the materials used and of the metals to be produced. All of the iron charged which is not blown from the top of the furnace as dust—amounting apparently to 9.6 per cent.[5]—is recovered in the metal. Of the manganese charged in the ferromanganese furnace, however, only 72 per cent. finds its way into the metal; about 15 per cent. of it being carried away unreduced in the slag and 13 per cent. being carried out at the top of the furnace with the gas, a loss that will be called, for convenience, the stack loss.

[2] C. P. Linville: Combustion Temperature of Carbon. *Trans.* (1910) **41**, 268.

[3] J. E. Johnson: Principles, Operation and Products of the Blast Furnace.

[4] A. L. Feild: The Viscosity of Blast-furnace Slag. *Trans.* (1916) **56**, 633.

[5] In addition to the Fe in the ore given in Table 3, the iron furnace received an average of 176 lb. (79.8 kg.) of mill-scale and 63 lb. (28.5 kg.) of scrap per ton of pig. The iron in the slag is negligible; 5 lb. (2.3 kg.).

Control of Furnace Losses

There are no silicon specifications to be met in the making of ferromanganese; the sulfur from the coke is taken care of as MnS in the slag, and, due to the large amount of coke in the charge, the stock is "loose," descending easily in the furnace without hanging or slipping. The operating difficulties, therefore, resolve themselves practically into the problem of keeping down the slag and stack losses. According to generally accepted ideas, the slag loss is reduced by operating with a highly basic slag, with a hot blast, and with plenty of coke. The results of the

Table 3.—*Comparison of Operating Data for the Ferromanganese Furnace and for the Iron Furnace*

	Ferro-manganese	Pig Iron		Ferro-manganese	Pig Iron
1 Ore per ton metal, lb.	5,992	3,937	22 CO in gas, per cent	31.00	23.57
2 Coke per ton metal, lb.	6,326	1,969	23 H_2 in gas, per cent	0.17*	0.17
3 Coal per ton metal, lb.	200	0	24 CH_4 in gas, per cent	0.21*	0.21
4 Stone per ton metal, lb.	2,349	984	25 N_2 in gas, per cent	58.36*	56.16
5 SiO_2 in ore, per cent	8.6	7.55	26 SiO_2 in slag, per cent	28.1	36.14
6 Al_2O_3 in ore, per cent	3.0*	1.96	27 Al_2O_3 in slag, per cent	14.0	13.33
7 Fe in ore, per cent	5.9	52.41	28 CaO in slag, per cent	−41.7	43.59
8 Mn in ore, per cent	40.3	0.61	29 MgO in slag, per cent	−41.7	4.50
9 SiO_2 in coke, per cent	6.5*	4.98	30 Mn in slag, per cent	10.6	0.53
10 Al_2O_3 in coke, per cent	3.0*	3.25	31 S in slag, per cent	....	1.49
11 F. C. in coke, per cent	85.5	87.64	32 Slag volume, lb.	3196	1,150
12 SiO_2 in stone, per cent	....	3.33	33 Blast temperature	1135° F.	1031° F.
13 Al_2O_3 in stone, per cent	....	1.28	34 Top temperature	690° F.	400° F.
14 CaO in stone, per cent	−52.0	48.20	35 Temperature combustion zone	2740° F.	2812° F.
15 MgO in stone, per cent	−52.0	3.64	36 Temperature of slag	2515° F.	2740° F.
16 C in metal, per cent	6.5*	3.80	37 Temperature of metal	2435° F.	2740° F.*
17 Si in metal, per cent	1.15	1.33	38 Wind per ton metal, lb.	24,000	8,012
18 Fe in metal, per cent	17.0*	93.85	39 Gas per ton metal, lb.	31,610	10,634
19 Mn in metal, per cent	74.9	0.87	40 Metal per day, tons	51.7	499
20 S in metal, per cent	0.01*	0.036	41 C burned at tuyeres	4,165	1386
21 CO_2 in gas (by weight) per cent	10.44	19.86	42 C absorbed by CO_2	946	169

* Estimated.

present investigation substantiate these ideas in a general way but carry them forwards from the realm of qualitative ideas and place them on the basis of a quantitative relationship. The question of stack loss has proved more difficult. According to these generally accepted ideas, the stack loss is supposed to increase in a vindictive sort of way whenever the slag loss is reduced. In particular, it is supposed to increase with the hearth temperature, with the basicity of the slag, and with the temperature of the top gas. The evidence offered by this investigation fails to support any of these theories; fails, in fact, to show any marked relationship between the stack loss and any other probably related quantity.

The problems connected with the determination and the control of these two losses will be discussed in the two following sections.

Slag Loss

The most self-evident statement to be made concerning slag loss, but the one that actually is seldom stated and often is forgotten, is that the pounds of manganese carried away by the slag equals the product of the slag volume and the percentage of manganese in the slag. The percentage of manganese in the slag is a physical quantity. Although perhaps it is not actually something green that can be seen, it is at least a quantity that the chemist reports every day. The product of this quantity multiplied by the slag volume (a figure the furnace operator works out probably once a year) is rather abstract and does not appear on the furnace records. In consequence, a low percentage of manganese in the slag has grown to be something of a commonly accepted criterion of good practice. Where the manganese content of the slag is reduced as a result of high blast temperature or by slow driving, it is a satisfactory guide. But if it is reduced by the addition of coke, especially a high-ash coke, the increase in slag volume may outweigh the advantage of a reduction in the manganese percentage of the slag with the result that the actual weight of manganese in the slag is greater.

Therefore, the first step in the problem of reducing the slag loss is to find a means of determining in advance the percentage of manganese in the slag, whatever value it may have, rather than to find by what means it may be made a minimum. The following attempt has been made to find a quantitative expression for this quantity:

Let M = percentage of manganese in slag;
B = ratio of $(CaO + MgO)/SiO_2$ in slag;
R = pounds of gross slag made per minute per square foot hearth area;[6]
T = blast temperature, in degrees F.;
V = slag volume, in pounds per ton of metal;
K = pounds of carbon in fuel per ton of metal.

The results of the 40 runs were plotted, first with pounds of carbon charged as ordinates and blast temperatures as abscissas, and second, with pounds of carbon charged as ordinates and slag volumes as abscissas. Through the points the two best straight lines were drawn, and from the

[6] Gross slag means the total weight of slag-forming materials, manganese being a slag-forming material. The evidence at hand points strongly to the conclusion that the MnO is reduced in the hearth. Therefore the pounds of this gross slag—a basic manganese aluminosilicate—formed per minute per square foot of hearth area is the best measure of the speed of operation. This rate of slag formation is given throughout in the unit of pounds per minute per square foot of hearth area.

slopes of these lines the variation in carbon fuel with blast temperature and with slag volume was determined. It was found that:

$$\left.\frac{dK}{dV}\right| T = \text{const.} = 0.88$$

and that

$$\left.\frac{dK}{dT}\right| V = \text{const.} = -1.33$$

hence, integrating these two formulas and determining the constant of integration

$$K_a = 4170 + 0.88\ V - 1.33\ T \tag{1}$$

That is, if for every degree increase in blast temperature the carbon is reduced 1.33 lb. (0.6 kg.) and for every pound increase in slag volume the carbon is increased 0.88 lb. (0.4 kg.), the hearth temperature conditions will remain constant.[7] It does not mean that the operator must increase the carbon charged 0.88 lb. for every pound increase in slag volume. Since usually the man burdening the furnace does not know what the slag volume is and does not admit that the figure 0.88 is correct, such a contention would be absurd. K_a in formula 1 is merely the carbon required with a given blast temperature and a given slag to maintain the average temperature conditions in the hearth. If he wishes, the operator can reduce the carbon charged until the hearth almost freezes or he can charge so much carbon that he bankrupts the owners, and the furnace will still make ferromanganese, even if it does not make money.

The value of K_a was worked out by means of formula 1 for each of the runs in Table 2, and the expression $K-K_a$ determined. This expression gives the excess or deficiency of the actual carbon charged above or below that required for average hearth temperature conditions, and will be called the "excess carbon." In the absence of pyrometer readings, it is the best guide to the temperature of the hearth. To show the relation existing between the percentage of manganese in the slag, the hearth temperature, the speed of operation, and the basicity of the slag, a similar procedure was adopted.

The figures in Table 2 were arranged, first, in order of decreasing "excess carbon" ($K-K_a$); second, in order of decreasing "speed of slag formation," and third, in order of decreasing slag basicity ($CaO + MgO / SiO_2$). Each of these series was broken into four groups and the vari-

[7] It must not be thought that K_a and K are two different variables, they are but two values of the same variable. K_a is not an operating quantity of the furnace, it is the carbon fuel that the furnace would receive if it were given the average fuel relative to its slag volume and blast temperature. If the actual fuel charged is more than K_a, it will cause the hearth to operate at a higher temperature; if it is less than K_a, the hearth will be at a lower temperature than the average. In fact $(K-K_a)$ is an arbitrary temperature scale, although it is not possible to connect its values with the thermometric scale.

ous figures averaged by groups. The results appear in Tables 4, 5, and 6. The significance of the first five columns is self-evident. The manganese in the slag is seen to be a function of three variables. In order to determine the effect of a change in one of these variables while the other two remain constant, it was necessary to apply the method of successive approximation. This somewhat tedious method shows that:

(a) $\frac{dM}{d(K - K_a)} = 0.0011$ if B and R are constant

(b) $\frac{dM}{dR} = 1.34$ if B and $(K-K_a)$ are constant

(c) $\frac{dM}{dB} = -9.16$ if R and $(K-K_a)$ are constant

Integrating the three formulas and determining the constants of integration,

$$M = 10.6 - 0.0011\,(K - K_a) + 1.34\,R - 9.16\,B \qquad (2)$$

Combining formulas 1 and 2, and multiplying the result by V,

$$\text{Slag loss} = MV = 15.2 + 1.34\,RV - 0.0011\,KV + 0.00088\,V^2 - 0.00133\,TV - 9.16\,BV \qquad (3)$$

The meaning of the last column in Tables 4, 5, 6 will now be apparent. In Table 4, the relation between M and $K - K_a$ is to be shown, but the values of B in the third column and R in the fourth column are not constant. The actual change is due largely to the change in $K - K_a$ but

TABLE 4.—*Variation of Per Cent. Mn in Slag with Excess Carbon*

Group of Runs	Excess Carbon, Pounds	Ratio Bases / SiO_2 in Slag	Rate of Slag Formation	Mn in Slag, Actual Per Cent.	Mn in Slag, Reduced Per Cent.
1	+754	1.69	1.84	8.2	10.3
2	+354	1.48	1.92	11.0	11.0
3	− 56	1.45	2.18	12.1	11.4
4	−765	1.37	2.36	13.3	11.8

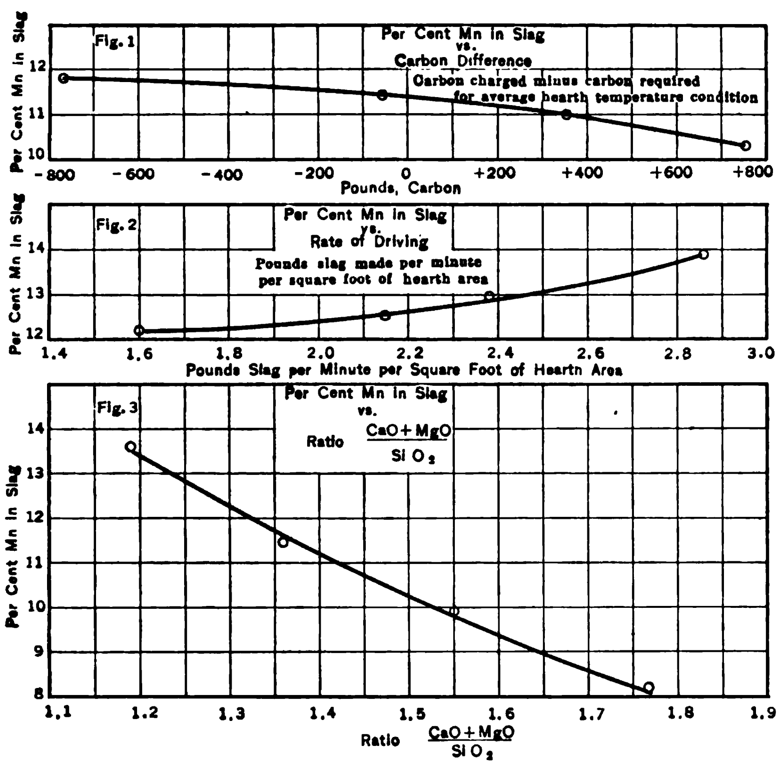
TABLE 5.—*Variation of Per Cent. Mn in Slag with Rate of Slag Formation*

Group of Runs	Rate of Slag Formation	Ratio Bases / SiO_2 in Slag	Excess Carbon, Pounds	Mn in Slag, Actual Per Cent.	Mn in Slag, Reduced Per Cent.
5	2.86	1.38	− 60	13.0	13.9
6	2.38	1.70	−312	12.0	12.9
7	2.15	1.51	− 62	12.6	12.5
8	1.60	1.64	+240	10.3	12.2

TABLE 6.—*Variation of Per Cent. Mn in Slag with Basicity*

Group of Runs	Ratio Bases / SiO_2 in Slag	Excess Carbon, Pounds	Rate of Slag Formation	Mn in Slag, Actual Per Cent.	Mn in Slag, Reduced Per Cent.
9	1.77	+411	1.79	7.4	8.2
10	1.55	+187	2.06	9.2	9.9
11	1.36	− 10	2.32	11.8	11.5
12	1.19	−110	2.42	14.2	13.6

to some extent to changes in B and R. The value of M for each group of runs is therefore reduced according to the relation (*b*) for changes in R and according to (*c*) for changes in B. The values of M given in the



FIGS. 1, 2, 3.

sixth column show the relation between M and $(K - K_a)$ alone, R and B being constant. The numbers in the first column of Table 4 are used as abscissas in Fig. 1, and the reduced values of M in the sixth column are used as ordinates. The results from Tables 5 and 6 are reduced in the same manner and plotted in Figs. 2 and 3.

The method for determining the formula for slag loss (formula 3) is admittedly rather involved, but this is due rather to the complexity of the relations involved than to the method of attacking the problem. The experimental errors throughout are very great; it is hoped, however, that by basing the formula on the average of a number of runs from a number of different furnaces, the effect of the errors is minimized. The correctness of the formula must be judged by the points plotted in Figs. 1, 2, and 3. The relation between M and the four independent variables K, B, R, and T is assumed to be linear, and it is seen that in each of the figures a straight line can be drawn which will pass within 0 5 per cent. of the actual value of M. The uncertainty in the value of the various quantities involved makes this much within the known experimental error.

Stack Loss

The 40 runs of Table 2 were divided into two groups according to the values of the stack loss for each run and the averages of these two groups are given in Table 7. Although the difference between the stack losses for the two groups of runs involves 14 per cent. of the total manganese charged, there is no noticeable relationship between it and the other

Table 7.—*Averages of Two Groups Formed from Runs of Table* 2

	Operation with High Stack Loss	Operation with Low Stack Loss		Operation with High Stack Loss	Operation with Low Stack Loss
Stack loss, per cent......	20.0	6.5	Silicon in metal, per cent.	1.19	1.11
Top temperature, degrees F..................	924	930	Rat'o of bases to silica..	1.54	1.52
			Excess carbon..........	+83	−20
Mn in slag, per cent.....	11.3	10.9	Rate of slag formation...	2.24	2.09

figures given in the table. With high stack loss, the top temperature is 6° F. less, the Mn in the slag is but 0.4 per cent. greater, the Si in the metal 0.09 per cent. greater, and the basicity ratio 0.02 per cent. greater. Hence none of these quantities apparently can be responsible for the great difference in stack loss. A difference in the right direction appears in the case of excess carbon; the high-stack-loss operation carries relatively 103 lb. (46.7 kg.) more carbon and since the average carbon charged is over 5000 lb. (2268 kg.) this 103 lb. is about 2 per cent. of the total. In the first place, since coke is charged by volume and not by weight, the least imaginable error in evaluating its weight will be more than 2 per cent.; further, if this difference in fuel is to account for the difference in stack loss, it must be concluded that 700 lb. (317.5 kg.) of excess carbon

would cause the stack loss to be 100 per cent The two values for the rate of slag formation are so nearly identical that this quantity can scarcely be a factor in the problem.

It should be remembered that the stack loss is the result of a computation involving four weights and ten chemical analyses, and further, that the nature of the computation is such that any errors in the determination of these 14 quantities accumulate. It is clearly demonstrated, it would seem, that more accurate data are needed on this point. In the absence of better information, it must be taken as a working hypothesis that the stack loss is not increased by a hot top, a basic slag, fast driving, or a high coke consumption. It is possible, of course, that the cause of stack loss has been overlooked entirely in this discussion, or that by some coincidence the errors have so arranged themselves as to mask the true result.

Burdening the Furnace

If this conclusion concerning the stack loss is accepted, formula 3 will be sufficient for determining in advance from the charge sheet the results to be expected from the furnace. Casual examination of Figs. 1, 2, and 3 will make it apparent that the reduction of the per cent. Mn in the slag by using excess carbon, or even by using the average carbon will hardly pay for itself. It would seem that in general the coke used has been more than was profitable. Also, the rate of driving has been too low, at least from the standpoint of furnace profits. The most effective method of reducing the slag loss is by carrying a highly basic slag. In nearly every case a ratio of bases to silica in the slag as high as 2.0 is practicable. This is 0.52 higher than the average basicity, 1.48 actually obtaining in the 40 runs. Formula 2 shows that an increase of 0.52 basicity will lower the percentage of Mn in the slag 4.77 per cent.; the addition of stone necessary to attain this basicity will increase the slag volume from 3196 to 3656. The manganese carried away in the average practice recorded is 10.6 × 3196, or 338 lb. (153 kg.). With a basicity of 2.0, the manganese in the slag would be 5.83 × 3656, or 213 lb. (96.6 kg.). The saving due to the change is 125 lb. (56.6 kg.) per ton of alloy, or about 5.25 per cent. of the manganese used. When the alumina content of the ore is high, it is possible to operate with a slag having a basicity of 2.5 or greater; in this case it is possible to bring the per cent. Mn in the slag down to 1.5 or 2.0 per cent.

The saving possible by changes of practice, while appreciable, are very much less than that resulting from the proper choice of materials. It can be shown, in fact, that by the use of low-silica coke and stone, the profits of the furnaces could have been doubled, and this with a saving of 9 per cent. of the ore and 38 per cent. of the coke used, and with a 50 per cent. increase in furnace capacity. It has been suggested that great

advantages are to be derived from a high blast temperature. The average blast temperature in Table 2 is 1136° F. (613° C.). It might be feasible to bring this average temperature up to 1700° F. (927° C.). According to formula 1, this would lower K_a 750 lb. (340 kg.) of carbon, or 13.5 per cent. The average run, however, could stand a deficiency of 750 lb. of carbon with an increase of only 0.83 per cent. in the manganese content of the slag, or a loss of about 1.1 per cent. of the manganese in the ore charged. This saving would undoubtedly be out of proportion to the trouble and expense needed to increase the blast temperature to 1700° F.

Accuracy of Result

As to the question of how much confidence should be placed in the results of this investigation, it must be remembered that the operating data recorded here are in general less reliable than would be expected by one acquainted only with iron-furnace practice. There are two reasons for this: (1) Manganese ores are extremely variable in character and in chemical composition. The difficulty of assigning a strictly representative analysis to the manganese-ore mixture charged on a given day is very great. Accurately to keep track of this one item would entail an amount of labor and expense that no furnace would be justified in incurring until it had been demonstrated that the resultant information would pay for itself. (2) Most of the manganese-furnace operations included in this investigation were undertaken and carried out at a time when it was impracticable to maintain the clerical force and the chemical laboratory required to keep perfectly satisfactory furnace records. It was a time, too, when the coke delivered at the furnace was becoming increasingly variable in composition.

Where relationships have been worked out, however, based on the average figures from a number of different furnaces, there is a tendency for any errors present to neutralize each other. It is reasonable to suppose, therefore, that the results given above are in general correct. That the results, if true, would be worth over $20,000,000 annually to the manganese-furnace industry means only that such an investigation was needed; the fact that they may be untrue means only that a more complete investigation is needed. The writer's purpose in working out these relationships was, in fact, largely to show the nature, extent, and value, of the results that can be obtained from an investigation of this kind.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Problems Involved in Concentration and Utilization of Domestic Low-grade Manganese Ore*

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(New York Meeting, February, 1919)

Contents

Introduction

The steel industry of the United States has depended in the past almost wholly upon imports for its supplies of manganese. Many of the important domestic sources yield ores leaner in their natural condition than the foreign ores the steel industry has been accustomed to use. To make them available, therefore, either the ores must be concentrated or the practice of the steel industry modified.

Roughly 25,000 T. annually of high-grade manganese ores are used for dry batteries, for chemical purposes, and in other ways; while approximately 750,000 T. are required for making steel.

By present practice, every ton of steel takes an average of about 14 lb. (1.8 kg.) of metallic manganese. This is generally added to the steel in the form of an alloy, the standard alloys being the 80-per cent. ferromanganese and the 20-per cent. spiegeleisen. During the year 1917 286,000 T. of ferromanganese and 193,291 T. of spiegeleisen were made in this country, the former largely from imported ores; and 45,381 T.

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† Formerly U. S. Bureau of Mines, Washington, D. C.

of ferromanganese was imported. The metallic manganese represented by these alloys was 304,000 T., the product of roughly 800,000 T. of high-grade ore and 345,000 T. of low-grade ore.

Manganese Deposits in the United States

Before the war manganese ore was mined in relatively small quantities in the Appalachian region, including Virginia, Tennessee and Georgia, and in Arkansas, but owing to the increase in prices during the past three years manganese mining has been undertaken also in Montana, California, Arizona, New Mexico, Nevada, Utah, and Minnesota.

From data now available it appears that in this country deposits of high-grade manganese ores are usually small, while materials lower in manganese and higher in iron occur in appreciable quantities. Our total quantity of manganese-bearing material is relatively large, but on account of the difficulty of mining small deposits and the apparent undesirability of the low-manganese material in the steel industry many difficulties present themselves.

Manganese-bearing materials of the United States may be roughly classified as follows:

1. Manganese ore proper.
2. Manganiferous iron ore.
3. Miscellaneous material.
    (*a*) Manganiferous silver and lead ore.
    (*b*) Zinc residuum from manganiferous zinc ore.

Manganese ore as now defined by the trade is material containing over 35 per cent. manganese and suitable for the manufacture of 70 per cent. ferromanganese. Manganiferous iron ore contains less manganese and more iron. Usually iron predominates but there is no hard and fast line of demarcation between manganese ore and manganiferous iron ore. Manganese and iron are usually closely associated in nature, and all gradations from very low manganese ores with high iron, to high manganese ores with low iron, may be met in various deposits or in the same deposit.

Manganiferous silver ore is similar to manganiferous iron ore, there being sufficient silver to make it valuable for that metal. It may be used for the production of manganese alloys and commercial considerations alone control the balance between the manganese or the silver value.

Zinc residuum is a byproduct from the smelting of certain zinc ores of Franklin Furnace, N. J., which contain considerable manganese. After the zinc is removed the remaining product, called residuum, is of nearly the same composition as natural manganiferous iron ore, and for a number of years has been used for making spiegeleisen.

Metallurgical Requirements of the Steel Industry

Manganese is principally used in the steel industry in the form of manganese alloys. A less important use is for increasing the manganese content of certain pig irons to give them particular qualities, as for foundry purposes, or to assist in metallurgical operations of certain steel-making processes, as in the basic open-hearth process. The alloys of manganese generally used in this country are ferromanganese, formerly containing 80 per cent., but now 70 per cent. metallic manganese, and spiegeleisen, containing from 15 to 20 per cent. metallic manganese. The remaining content of these alloys is principally iron with small quantities of carbon, silicon and phosphorus.

For the past few years ferromanganese has been gaining in popularity with steel manufacturers, spiegeleisen declining proportionately. Until recently approximately nine-tenths of the metallic manganese used in the steel industry was in the form of the standard 80-per cent. alloy. "Ferro," as it is usually called, is easier to use than alloys containing smaller quantities of manganese, as the required quantity of that metal is contained in smaller bulk.

The difficulty of obtaining ores suitable for the production of "ferro" during the past few years has led to the consideration of using what may be called intermediate alloys with manganese contents varying between 20 and 80 per cent. In the electric furnace certain alloys can be made with a relatively large content of silicon in addition to the manganese and iron. The extent to which such alloys may satisfactorily be used in steel manufacture is not alone a technical or economic problem, but is largely controlled by the prejudice of steel masters against deviating from established practice.

Phosphorus is an undesirable element in finished steel. In the manufacture of manganese alloys all the phosphorus contained in the ore will enter the alloy and will be introduced into the steel when the alloy is added. It is permissible, however, for an alloy high in manganese to contain more phosphorus than one low in manganese, for in the former case less alloy is needed to introduce a given quantity of manganese.

For many years manganese alloys have been principally manufactured in the blast furnace, although recently certain plants have produced them in the electric furnace. The operation of a blast furnace on manganese alloys is in general similar to ordinary pig-iron practice, but there are high metal losses, principally in the slag and in the stack. The manganese content of the slag may be partly controlled by furnace manipulation, but it is evident that the total loss in this manner is directly proportional to the slag volume.

The results of increased slag volume are cumulative and serious. The accompanying increased loss of manganese requires that more ore

be used per ton of alloy produced. The additional ore introduces more slag-forming constituents, requiring more coke to melt it, which in turn tends to produce more slag, while increased slag volume cuts down the daily output of alloy. The greater manganese loss decreases the ratio of manganese to iron in the alloy and unless proper allowance is made the alloy will be below the standard grade and therefore subject to penalty by the purchaser. Not only will the alloy sell for less, but the decreased daily output will lessen the total profits.

The alloy manufacturer endeavors to protect himself against these decreased profits by adjusting schedules for ore purchase. Although the endeavor is made to equalize the effects of poor ores in furnace practice, the alloy producer would prefer to buy better ores and pay correspondingly more, whenever they are available.

Concentration of Domestic Low-grade Manganese Ores

The comprehensive term, concentration, as here used, is intended to include the improvement of low-grade material by any suitable means preliminary to smelting. The requirements of metallurgical practice control the classification of manganese materials into low-grade and high-grade. In some cases, the term low-grade may refer to a low manganese content with respect to iron or to large quantities of non-metallic impurities. The detrimental effect on metallurgical practice and the resulting penalties are incentives for attempts to improve the material or raise the grade before smelting.

Factors Controlling the Possibilities of Concentration

In order to properly interpret the possibility of commercially concentrating any type of manganese-bearing material, it is necessary to consider many technical and economic factors. For a particular property, district, or class of material it is necessary to obtain data on the following factors:

1. Character and size of the deposits.
2. Conditions affecting mining and marketing.
3. Character of ore material as affecting the possible improvement of grade.
4. Metallurgical value of crude ore and possible concentrate.
5. Commercial considerations.

Size and Character of Deposit

Obviously a deposit containing a large quantity of low-grade ore would warrant considerable experimental work in order to determine methods of treatment. Conversely, if a particular type of material

occurred in only one deposit and contained but a few thousand tons, it is evident that the value of the product to the industry at large would be relatively small, even if it were possible to concentrate it. Therefore proper perspective should be obtained in order that no undue proportion of time be devoted to a concentrating problem which may be of considerable technical and individual interest but which would assist little toward furnishing any considerable portion of the industry's needs.

In other words, the mineralized mass must be of such size and character as to justify the expenditure of money in its development and beneficiation and return interest on the investment proportional to the risk taken. This factor is of vital importance and it is feared that under the stimulus of production incident to national needs during the war, sound business principles have at times been overlooked.

Conditions Affecting Mining and Marketing

In addition to the classification of deposits on the basis of quantity and character, it is necessary to determine the natural factors controlling mining methods, transportation facilities and marketing.

The manganese deposits of the United States, while widely scattered and comparatively small, may nevertheless be mined by relatively simple and therefore cheap methods. The mines are for the most part shallow, so that extensive, non-productive development and elaborate equipment are not necessary. Intricate problems of ventilation and drainage have not to be solved, and if all operations are competently directed, common mine labor will generally suffice. Limited tonnage means short life, and temporary support of excavations following more or less crude mining practice prevails. The cost of mining, however, will be more or less governed by the necessity of selective mining which in turn is determined by the variability in character of the ore, the feasibility of economic concentration, the transportation facilities and the distance from a consuming center. All these factors must be properly coördinated and their combined influence studied before intensive production from individual properties is started. By the elimination of waste, concentration may yield a product desired by the steel industry, but the cost may be prohibitive. The reduction of weight resulting from waste discard may enable the producer to offset excessive freight rates, but geographic isolation will invariably handicap an enterprise. Foreign ores will always find a market in the United States since the deposits from which they come are larger and more uniform in character, while the wage scale is low and railroad transportation can never compete with ocean freight.

Characteristics of Ore Affecting Beneficiation

Character of Manganese Minerals

There are a great number of minerals containing manganese, but relatively few that are commercially important. Usually it is rather difficult to identify accurately the manganese minerals contained in domestic oxidized ore. Several minerals may occur in more or less intimate association, and in some cases one has been formed by alteration of another. The hardness of the individual minerals varies widely. Pyrolusite is soft and may be readily pulverized between the fingers. Difficulty might be expected, therefore, in attempts to recover this mineral by the common processes of wet concentration. The other minerals are harder but usually brittle. While the character of the individual minerals is important, the association of the several manganese minerals with the gangue materials and the relation thereto often has a more important bearing upon the problem of concentration.

Impurities Associated with Manganese Minerals

Manganese ore mined on a commercial scale always contains impurities. The presence of some of these will be obvious by simple inspection, while others may require chemical analysis for their determination. The impurities associated with manganese minerals may be classified as: (1) Those derived from associated rocks or rocks partially replaced by manganese-bearing solutions, (2) those associated with the manganese in solution and deposited simultaneously, and (3) those chemically combined with manganese in the mineral. From the metallurgical viewpoint all are impurities and must be removed either before metallurgical treatment or by it.

For convenience the common impurities in manganese ores may be classified according to certain general physical and chemical principles as follows:

1. Metallic: Iron, lead, zinc, silver, and in some cases, nickel, copper and tungsten.
2. Gangue: "Basic" lime, magnesia, baryta; "acid" silica and alumina.
3. Volatile: Water (atmospheric moisture and molecular water), carbon dioxide, organic matter.
4. Miscellaneous: Phosphorus and sulfur.

The chemical behavior of these impurities affects metallurgical operations, while the physical form in which they occur controls the possibility of removal previous to smelting, and the choice of methods of removal.

The proportion of manganese to useless or harmful constituents of the ore determines its value and desirability. The presence of appreciable quantities of any impurity means that more ore must be mined and smelted to produce a given weight of alloy. Some impurities, however, are more detrimental than others.

Metallic impurities, of which iron is the most common, will usually be reduced and retained by the alloy. The quantity present controls the desirability of the alloy for use in steel manufacture. Metallic impurities other than iron occur usually in such small quantities that they are not detrimental to the resulting alloy. Zinc is an exception; it is largely volatilized in the smelting and, if present in appreciable quantities, the fume will condense as oxide in the hot-blast stoves, which may interfere with furnace operations. Unless the furnace top gases are washed the stoves must frequently be cleaned, with consequent loss of time. When the price of zinc is high, the zinc oxide recovered from the stoves yields a substantial sum. Silver is neither detrimental to manganese alloys, from the standpoint of steel manufacture, nor advantageous. The silver content of a manganese alloy has no value, consequently no credit is allowed the miner for silver contained in an ore when it is to be used for manganese-alloy manufacture. In some cases the quantity of silver in a magniferous ore is such that it has greater value for the lead smelter. The manganese then acts as a flux.

The gangue impurities, classed above as basic and acid, may also be called slag-forming impurities. In smelting these impurities must be fluxed to form slag. Slag is usually considered a waste product of a smelting operation, but it has important metallurgical functions, and just sufficient slag must be present to perform those functions properly and economically. An excess of slag must be avoided. In manganese-alloy manufacture the slag contains more or less manganese which does not enter the alloy. The quantity of manganese thereby lost is dependent upon the basicity of the slag, the temperature, and the slag volume. The first two factors control the quantity of manganese in a given weight of slag, while it is obvious that a greater slag volume will result in a greater loss of manganese.

Silica is usually the predominating slag-forming constituent in domestic manganese ores. A certain quantity of silica is reduced to the metallic state in the smelting operation and is recovered in the alloy as silicon, but the larger part must be fluxed with lime, magnesia or other bases to form slag. Manganese-alloy slags should be basic, hence a larger quantity of slag will be produced from an ore with acid gangue than in normal iron blast-furnace practice. Alumina is a slag-forming constituent, and while usually classed with silica, it acts somewhat differently in blast-furnace operations. Brazilian ores are notably high in alumina but most domestic ores contain relatively small quantities.

Lime, magnesia and baryta in an ore are also slag-forming constituents, but they combine with the silica and alumina present and thereby reduce the quantities of these bases necessary in the form of limestone or dolomite for the furnace charge. Baryta is not common as a gangue mineral. It is not so strong a base as either lime or magnesia. While these constituents offset the metallurgical effects of silica or alumina, from the standpoint of evaluating an ore they represent weight; and if the ore must be transported a considerable distance to be smelted, it is doubtful whether their value as bases will equal the additional freight charge. Limestone can generally be obtained at low cost close to the smelter.

Volatile impurities are removed from the top of a blast furnace largely by the surplus heat. It is desirable, however, in order to reduce the loss of manganese from this cause to keep the top of a manganese-alloy blast furnace cool. Volatile compounds are not particularly detrimental to smelting. When carbonate ores are being treated the case is somewhat different, some metallurgists claiming that in treating rhodochrosite ores the ratio of carbon monoxide to dioxide in the furnace gases is disturbed, which has a detrimental effect on the reduction of the oxides of manganese in the upper part of the furnace. It has also been suggested that the carbon dioxide driven off combines with carbon of the coke, forming carbon monoxide in the upper part of the furnace, and thus increases the coke consumption. Definite data are not available on these points.

From the practical standpoint all the phosphorus in the ore mixture, together with that contained in the coke and limestone, is recovered in the resulting alloy. The permissible quantity of phosphorus in an alloy, such that it does not produce detrimental effects when added to steel, has not been definitely determined. The higher the manganese content of an alloy, the larger is the quantity of phosphorus that may safely be contained. Ordinarily steel makers desire as large a margin of safety as possible and therefore have specified that phosphorus shall not be above a certain percentage in an ore.

Sulfur usually exists in relatively small quantities in oxidized manganese ores, but in the case of the primary rhodochrosite ores of Butte and other parts of the West there may be present considerable quantities of sulfides of iron and zinc. Sulfur is not a serious factor, as the conditions of blast-furnace operation, when making manganese alloys, are such that sulfur combines with manganese or lime and is readily retained by the slag, only traces entering the alloy.

Knowing the effect of impurities in manganese ores on blast-furnace practice, the methods of eliminating them may be considered. Ore-dressing deals with the separation of deleterious or useless materials from the more valuable minerals, thereby raising the grade and reducing

the quantity of the concentrated product. To accomplish this it is essential that the physical and chemical characteristics of the ore be determined. These factors are governed largely by the type of deposit from which the ore is mined. As types of ore, entirely disregarding genesis, we recognize:

1. Rhodochrosite and rhodonite; carbonate and silicate ores, deposited in fissure veins or replacing original rocks.

2. Nodular ores: accretions of manganese oxide in soft plastic clays.

3. Manganese oxides deposited in small fissures or fracture planes, as breccia fillings, or as more or less impure beds.

4. Manganese oxides occurring as infiltrations, deposited in minute pore spaces, as particle replacements, or otherwise intimately mixed with the rock or gangue.

In the first class of deposits the principal gangue impurity is silica, although sulfides of silver, lead, zinc and iron are often found in appreciable quantities. The silica occurs both as quartz and chemically combined in rhodonite ores. In the carbonate ore, the carbon dioxide may be removed by calcination, thus effecting a concentration, but rhodochrosite decrepitates strongly when heated to a temperature where the oxide is formed, tending to produce an excessive quantity of fine material which is undesirable in practice. The breaking up of the particles by calcination will isolate some of the free silica, which on account of its larger sized particles may be screened out. The sulfide minerals may occur in such quantity that it is desirable to remove them by gravity methods of separation.

In the second class of deposits the nodules are of variable size and usually high in manganese. They do not appear to be contaminated internally with the inclosing material. The clays are soft, whereas the nodules are generally hard. This type is common in the Appalachian region of the United States. The clay may be separated from the manganese nodules by means of log washers, followed, where necessary and where the size of the deposits warrants the installation, by picking-belts, crushers, screens, and jigs.

With deposits of the third class the manganese minerals, although closely associated with the inclosing rock, are not generally contaminated by it and may be relatively pure. The method of treatment will vary with the size of the manganese particles and the hardness of the rock but will not differ essentially from the treatment of the second class. If there is little or no clay, the log washer will be omitted, while crushing, screening, jigging, and possibly tabling will make up the concentrating process.

It should be noted that if the mineral is largely pyrolusite, and therefore friable and soft, crushing may produce an excessive quantity of fine material, composed of manganese minerals which are difficult

to recover by means of gravity or water methods of separation. If, however, the manganese mineral is of a hard, dense, massive variety, and the inclosing rock more friable, the problem is simpler. When the specific gravities of the minerals and the gangue approximate each other wet concentration is difficult unless there be a marked difference in the size of particles.

From the standpoint of concentration it is obvious that the association of gangue materials with the desired mineral in ores of the fourth class is so intimate that the finest crushing imaginable would not permit of separation by mechanical means. To this type the siliceous manganese ores of the Western States may be assigned. Ore-dressing experimentation has conclusively shown that where the silica is chemically combined with the manganese or where colloidal silica envelopes the manganiferous particles, wet-process or gravity concentration will not give the desired results.

Concentration of Manganese Ores

It is not within the scope of this paper to describe in any detail actual ore-dressing or concentration practice. It is axiomatic that small deposits or mines of questionable life do not warrant elaborate plans or the adoption of intricate beneficiation processes. A general classification of methods applicable to the manganese industry is given below. These are all preliminary to the greater and final concentration of the desirable elements in the blast furnace from which the ferro-alloy is produced.

Simple Methods of Concentration:

- (*a*) Selective mining.
- (*b*) Hand picking.
- (*c*) Jigging.
- (*d*) Screening.
- (*e*) Log washing.
- (*f*) Water classification.
- (*g*) Roughing table treatment.
- (*h*) Slime table or vanner treatment.
- (*i*) Pneumatic separation.
- (*j*) Combination of two or more of the above.

Complex Methods:

- (*a*) Magnetic separation:
  1. Without preliminary thermal treatment.
  2. With preliminary thermal treatment.
- (*b*) Electrostatic separation.
- (*c*) Hydrometallurgical processes:
  1. Leaching with various acids, precipitation by chemical substances.
  2. Leaching with various acids, precipitation by electrolysis.
  3. Leaching with various acids, evaporation of solution and heat treatment in rotary kiln.

(d) Preliminary thermal processes:
   1. Drying, to remove hygroscopic moisture.
   2. Calcining, to remove carbon dioxide or combined water.
   3. Agglomerating fine concentrates to make them desirable for blast-furnace use.
   4. Volatilizing manganese at high temperatures in the presence of certain constituents which form readily volatile compounds.
   5. Direct reduction of oxides by carbon, under temperature control.

(e) Miscellaneous processes:
   1. Flotation.
   2. Use of heavy solutions.

There are many standard machines for the concentration of ores based on certain principles or combinations of principles, but it is unwise and usually unsatisfactory to begin with the idea that a certain machine will accomplish the necessary result on manganese-bearing materials. As the character of the manganese materials varies greatly in different districts, it is more logical to determine first the detailed physical and chemical characteristics of the material. When such preliminary study has shown the nature of the impurity and its relationship to the manganese mineral, it is easier to outline the general methods of treatment which might reasonably be expected to accomplish the desired result. The flow sheet, however, must be determined by experimental work.

Commercial Considerations

If the technical possibilities of beneficiating an ore have been favorably determined, it is then necessary to ascertain whether such an operation could be conducted on a commercial scale and a reasonable profit made. The cost of the plant and its installation must be justified either by the available ore, or upon the length of time during which the profit could be made. The amortization of capital and interest on the investment must be included in the estimation of cost.

The effect of concentrating an ore is not always clearly appreciated. Concentration implies that an improvement of metallic content is made by the intentional elimination of impurities, but by so doing there is always a loss of the valuable mineral itself. When the grade of material is increased, the weight is decreased. In other words, in some cases from 2 to 25 T. of crude material may be necessary to produce 1 T. of high-grade concentrate. The income results from the sale of the smaller quantity of concentrate, but chargeable against this, will be the mining cost of the several tons of crude ore necessary to make that concentrate, the actual cost of treating the ore, the freight to market, and special overhead charges. Concentration may be necessary, however, to make the material marketable at all.

A detailed study of each project is necessary to determine the cost of mining, preparation of the ore, selling price of both crude ore and concentrates on the existing schedules, and the possible resulting profit or loss in either case.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Effect of Cold-working and Rest on Resistance of Steel to Fatigue under Reversed Stress*

BY H. F. MOORE,† M. M. E., AND W. J. PUTNAM,‡ B. S., URBANA, ILL.

(New York Meeting, February, 1919)

THIS paper gives a preliminary summary of results of tests on the resistance to fatigue under reversed stresses of steel subjected to cold-working and of tests to determine the effect of rest on the endurance of steel under reversed stresses. The tests of cold-worked steel were undertaken as part of an investigation by the National Research Council Committee on Fatigue Phenomena of Metals and were made by Mr. Moore; the tests to determine the effect of rest are part of an investigation now being made by Mr. Putnam. Both series of tests were made in the Materials Testing Laboratory of the University of Illinois. The preliminary results of these tests are reported now because it is believed that test data on fatigue strength should be available at the earliest possible moment; however, it should be clearly kept in mind that this paper gives preliminary results and is intended to encourage discussion rather than to give final conclusions. Before giving the data of the tests, the writers will explain the term "fatigue strength" as used in this paper and will discuss briefly the method used in interpreting the test data of repeated-stress tests.

The term fatigue strength, as applied to a material, may be defined as that maximum fiber stress that will cause fracture of the material after the repetition of any given number of cycles of stress, each cycle involving the variation of stress from a minimum to the above maximum. The fatigue strength, then, varies with the number of repetitions occurring in the lifetime of a structural or machine member and with the range of stress for each cycle of stress. The fatigue strength will be lower for a member in which the stress is completely reversed than for one in which the stress varies from zero to a maximum.

In interpreting test data from fatigue tests under reversed stress, the stresses and corresponding numbers of repetitions required for failure are plotted on logarithmic cross-section paper. In 1910, Professor

* Report of research under the auspices of the National Research Council.

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Basquin of Northwestern University pointed out[1] that over a considerable range the relation of fiber stress and number of repetitions required for failure was given by the formula

$$S = \frac{K}{N^q}$$

in which S = intensity of extreme fiber stress, in pounds per square inch;
N = number of repetitions required to produce failure;
K and q = constants, depending on variation of stress, method of loading, etc.

This formula may be written

$$\log S = \log K - q \log N$$

If values of $\log S$ and $\log N$ are plotted on ordinary cross-section paper or values of S and N are plotted on logarithmic cross-section paper the foregoing formula is represented by a straight line.

How far a formula of this form represents the behavior of materials under repeated stress is an unsolved question. If such a formula were true for all values of S and N, the limit of stress for an infinite number of repetitions would be zero. Without taking time to discuss the limits of this formula, it may be pointed out that by its use a very clear graphic comparison of the results of two series of tests on different materials can be made. The relative stress ordinates for any given value of N give the fatigue limits of the materials for that particular length of life; a comparison of the steepness of the lines representing the test results shows whether the two materials have the same relative fatigue strength for different lengths of life.

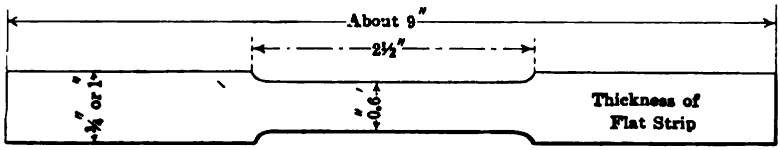
Tests of Cold-worked Steel

It has been known for many years that the elastic limit, the yield point, and, to a less degree, the ultimate strength of steel may be raised by cold-working if a period of rest ensues after the cold-working. There are very few test data on the fatigue strength of cold-worked steel under repeated stress, and tests were undertaken to throw some light on this question whether increased fatigue strength accompanied increased dead-load or static strength due to cold-working of steel.

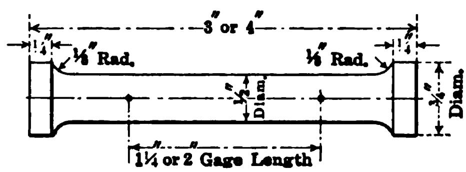
Three series of tests were made: (1) Tests on specimens of hot-rolled steel and on corresponding specimens from the same piece after being cold-worked by stretching with a fiber stress of 57,000 lb. per sq. in. (40.05 kg. per sq. mm.) (corresponding elongation about 0.05 in. per in. of length). (2) Tests on specimens of cold-rolled steel and on corre-

[1] O. H. Basquin: Exponential Law of Endurance Tests. *Proc.* Amer. Soc. Test. Mat. (1910) **10**, 625; see also G. B. Upton and G. W. Lewis: The Fatigue Failure of Metals. *Amer. Machinist* (Oct. 17 and 24, 1912) **37**, 633, 678.

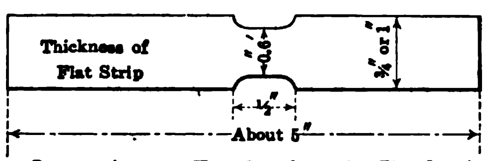
sponding specimens from the same rod annealed to remove the effects of cold-rolling. (3) Tests on annealed specimens of hot-rolled steel and on corresponding specimens from the same rod cold-worked by transverse compression with a fiber stress of 60,000 lb. per sq. in. (42.16 kg. per sq. mm.) (corresponding unit compression about 0.034 in. per in. of thickness).



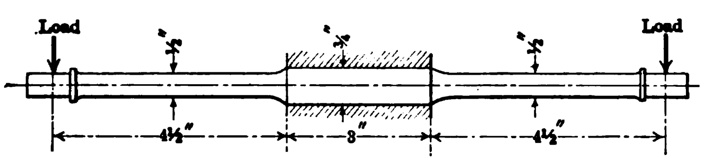
Tension Test Specimen for Flat Steel



Tension Test Specimen for Round Steel



Reversed-Stress Test Specimen for Flat Steel
(Upton-Lewis Machine)



Reversed-Stress Test Specimen for Round Steel
(White-Souther Machine)

FIG. 1.—FORMS OF TEST SPECIMENS USED.

All steel tested had a carbon content of about 0.20 per cent. In series (1), some specimens were tested immediately after cold-stretching, others were tested after cold-stretching and boiling in water for 15 min., and still others were tested after cold-stretching and then resting for 60 days. In series (3), the cold-pressed specimens were tested after cold-pressing, boiling in water for 15 min., and resting about 2 days.

Static tension tests were made in a 100,000-lb. (45,359-kg.) Riehle

testing machine; Fig. 1 shows the shape of the tension test specimen used. In reporting results of static tests the proportional limit and the American Society for Testing Materials, A. S. T. M., elastic limit are reported. The proportional limit was determined from a stress-strain diagram, and the extensometer used had a gage length of 2 in. (50.8 mm.) and a sensitiveness of reading of 0.00002 in. (0.0005 mm.). The A. S. T. M.

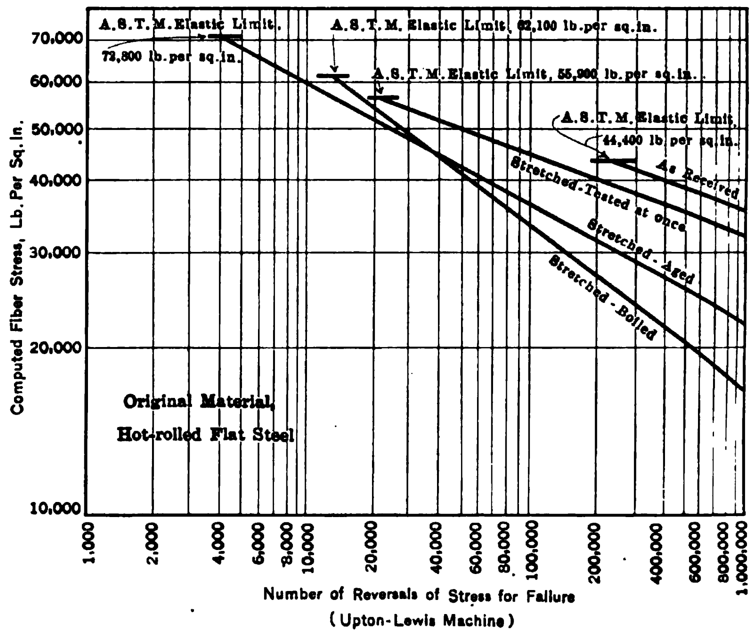


FIG. 2.—TESTS OF COLD-STRETCHED FLAT STEEL

elastic limit, which is determined by the sudden increase of rate of stretch of the specimen as shown by the extensometer[2] is believed to be a good criterion of the static elastic strength of a metal.

Fatigue tests were made in an Upton-Lewis vibratory testing machine running at 250 vibrations per minute.[3] This machine gives complete reversals of bending stress on a flat specimen. Fig. 1 shows the form of fatigue test specimen used.

Table 1 gives the results of the static tests and Table 2 the results of the fatigue tests. Figs. 2, 3, and 4 show graphically the results of the tests. In plotting the results of the fatigue tests logarithmic coördinates were used. Nominal or computed stresses were laid off as ordinates and numbers of repetitions required to produce failure were laid off as abscissas. The points, plotted on logarithmic paper, formed fairly straight

[2] *Standards*, Amer. Soc. Test. Mat. (1918) 163.

[3] For a description of the Upton-Lewis machine see *Bull.* 98, Engineering Experiment Station, University of Illinois.

lines for each set of fatigue tests, and in Figs. 2, 3, and 4 the inclined straight lines are the most probable straight lines representing the plotted points as determined by the method of least squares.[4]

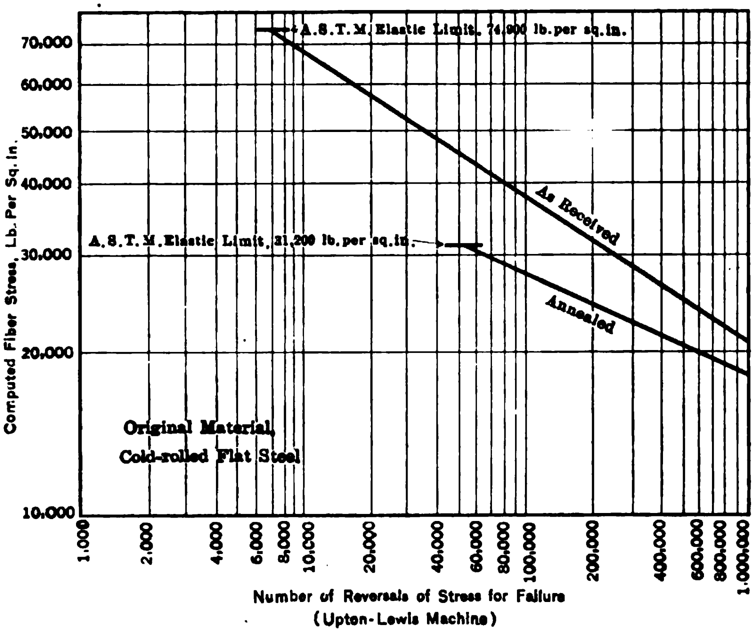


FIG. 3.—TESTS OF COLD-ROLLED FLAT STEEL.

TABLE 1.—*Average Results of Static Tension Tests*

Material	Treatment	Unit Stress, Lb. per Sq. In.		
		Proportional Limit	A. S. T. M. Elastic Limit	Ultimate
Steel from flat strip, hot-rolled	None	40,300	44,400	61,300
Steel from flat strip, hot-rolled	Cold-stretched and tested at once	26,800	55,900	60,300
Steel from flat strip, hot-rolled	Cold-stretched, boiled 15 min.	61,200	62,100	68,700
Steel from flat strip, hot-rolled	Cold-stretched, aged 60 da.	57,200	72,800	77,400
Cold-rolled	None	47,300	74,900	89,900
Cold-rolled	Annealed	27,100	31,200	60,500
Steel from flat strip, hot-rolled	Annealed	30,400	33,300	53,100
Steel from flat strip, hot-rolled	Cold-pressed, boiled 15 min. aged 2 da.	40,500	48,500	62,700

[4] Tuttle: "The Theory of Measurements," 242.

TABLE 2.—*Results of Fatigue Tests*

Specimen Mark	Treatment of Specimen	Nominal Fiber Stress, Lb. per Sq. In. S	Number of Repetitions at Failure N
	Specimens from hot-rolled flat strip		
5	None	40,800	303,600
11		70,900	6,100
16		41,900	288,600
21		79,400	3,400
26		45,700	221,300
32		72,000	8,100
6	Stretched to a fiber stress of 57,000 lb. per sq. in. and tested immediately.	40,500	472,000
9		67,100	5,800
15		41,100	126,800
23		45,400	118,500
25		67,200	4,600
31		62,200	21,200
7	Stretched to a fiber stress of 57,000 lb. per sq. in., boiled 15 min. and tested.	63,700	13,300
12		29,100	226,700
14		76,200	4,800
22		70,500	11,700
28		31,500	112,500
29		22,100	490,500
8	Stretched to a fiber stress of 57,000 lb. per sq. in., aged 60 days and tested.	53,600	30,700
10		44,200	108,600
13		58,000	35,500
24		35,800	120,800
27		31,400	198,200
30		62,200	4,800
	Specimens from cold-rolled strip 1 in. by ¼ in.		
.:.	Cold-rolled as received.	51,600	36,800
...		51,900	17,100
:::		60,600	10,900
:::.		24,700	188,000
::::.		37,900	192,700
:::::.		46,800	83,600
.	Annealed from 1450° F.	37,900	23,000
....		35,400	20,400
.....		39,800	10,500
::::		22,200	635,400
:::::		26,900	92,300
::::::		28,800	46,500

TABLE 2.—*Results of Fatigue Tests*—(*Continued*)

Specimen Mark	Treatment of Specimen	Nominal Fiber Stress, Lb. per Sq. In. S	Number of Repetitions at Failure N
	Specimens from hot-rolled strip ¾ in. by 5/16 in.		
B	Annealed from 1350° F.	77,500	1,600
D		75,000	7,100
F		54,000	26,200
H		47,600	86,800
J		28,900	593,600
A	Annealed from 1350° F, compressed sidewise under a fiber stress of 60,000 lb. per sq. in., boiled, and aged 2 days.	62,500	24,800
C		50,600	157,700
E		40,800	259,000
G		60,700	19,700
I		63,400	6,700
K		66,600	6,000

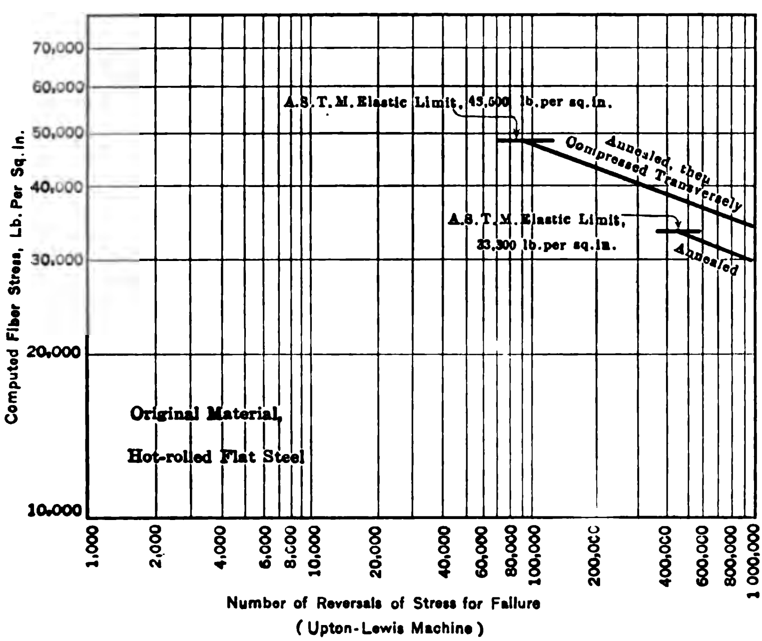


FIG. 4.—TESTS OF FLAT STEEL COMPRESSED TRANSVERSELY.

The A. S. T. M. elastic limit is regarded as the upper limit of elastic strength under any condition and so in Figs. 2, 3, and 4 the inclined straight lines are terminated at their upper ends at an ordinate value representing the A. S. T. M. elastic limit. The values of the A. S. T. M.

elastic limit represent the relative *static elastic strengths* for the different materials and for any given number of repetitions of stress the *fatigue strength* is represented by the ordinate to the inclined line, except for stresses higher than the elastic limit. The inclined lines were determined from the data given in Table 2. The part of the inclined line above the static elastic limit is omitted.

The tests indicate that an increase in the static strength of medium steel due to cold-working does not necessarily indicate increased resistance to fatigue under repeated stress. In interpreting the results of the fatigue tests, it should be borne in mind that if the inclined line representing the test results is steeper for cold-worked material than for material as received or annealed it indicates that for low fiber stresses, and corresponding high numbers of repetitions for failure, the increased fatigue strength due to cold-working diminishes. In the case of cold-stretched material, Fig. 2, for low stresses the fatigue strength of the cold-worked material was found to be actually less than the fatigue strength of the material as received.

For commercial cold-rolled steel, the tests show an apparent approach to equality of strength to resist fatigue between cold-rolled steel and annealed steel as lower stresses are used. It would seem to be rather doubtful whether for working stresses cold-rolled steel would show higher fatigue strength than hot-rolled steel of the same composition. This is also indicated by the relative slopes of the lines for cold-rolled steel and for hot-rolled steel shown in Fig. 5.

The results of tests of cold-pressed steel are interesting in that they show a slight improvement in fatigue strength of steel after cold-pressing as contrasted with diminished fatigue strength after cold-stretching. This result should be confirmed by further tests before being accepted.

Tests on the Effect of Rest

There have been various positive statements that steel subjected to reversals of stress will have its life materially increased if it is allowed resting periods, and it has been experimentally demonstrated by Bauschinger, Hancock, and others that the static elastic strength of overstressed steel is increased by rest. The study of the effect of rest on fatigue strength was the object of the following tests. It was assumed at the start that the rest period should be about such as a machine part would receive in actual practice. Specimens were subjected to repeated stress for one-third of their life, as found by continuous runs to failure on several similar specimens, and were allowed to rest 24 hr. The specimens were then subjected to repeated stress for a second third of their life and again rested for 24 hr. This process was repeated till failure occurred. Each specimen tested with resting periods, therefore, had at

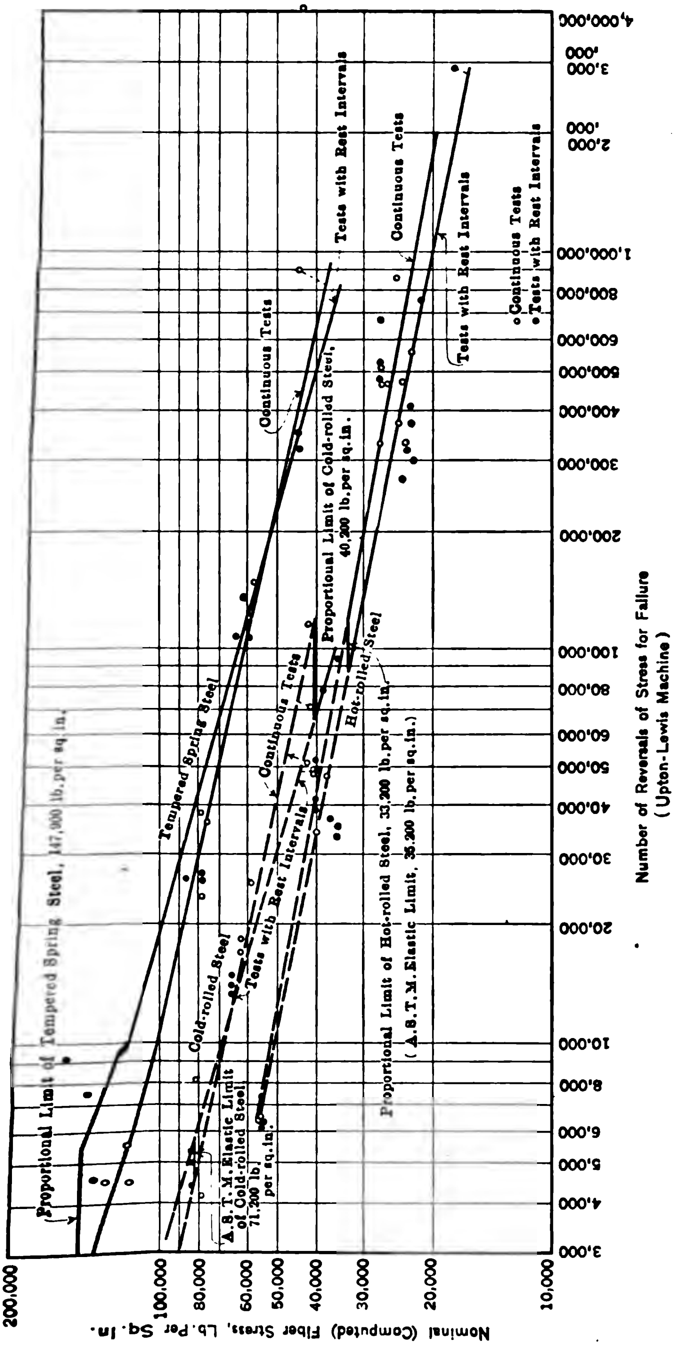


FIG. 5.—FATIGUE TESTS WITH AND WITHOUT REST INTERVALS.

least two rest periods of 24 hr. each. There is an infinite number of other combinations of number and duration of resting periods that could be tried, but it was thought that if rest has a marked effect in increasing life the fact would be evidenced by these tests.

Four series of tests on three different materials were made in the Upton-Lewis vibratory testing machine and four series on four materials were made in a White-Souther rotating testing machine.[5] Static tension tests of the material were made as already described. Table 3 gives the average results of static tests and Table 4 the data for the fatigue tests.

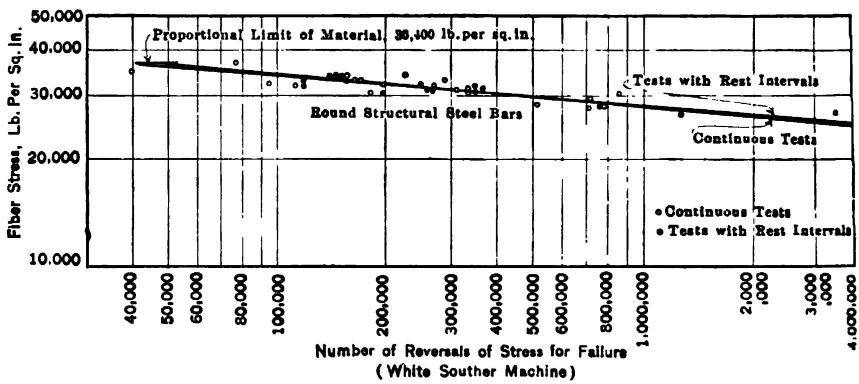


FIG. 6.—RESULTS OF FATIGUE TESTS OF ROUND STRUCTURAL STEEL BARS.

The test specimens used are shown in Fig. 1. Fatigue-test data plotted on logarithmic paper are shown in Figs. 5 to 9. Fig. 5 shows the results of tests made on the Upton-Lewis machine and Figs. 6 to 9 show the results from the White-Souther machine. From the curves no marked benefit of a short period of rest on the fatigue strength of steel can be detected.[6] This is especially true for stresses within the limit of proportionality of the material.

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[5] *Proc.*, American Society for Testing Materials (1907) **7**, 616.

[6] The tests on the Upton-Lewis machine show slightly greater fatigue strength under low stresses for the continuous tests. The tests on the White-Souther machine show slightly greater fatigue strength for the tests in which the specimen is given periods of rest.

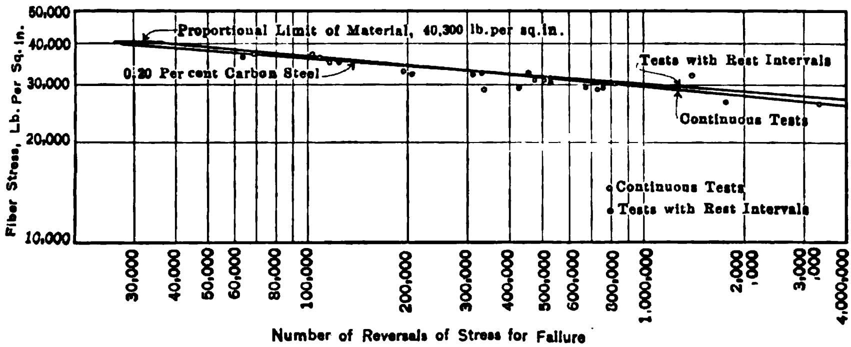


FIG. 7.—RESULTS OF FATIGUE TESTS OF 0.20 PER CENT. CARBON STEEL.

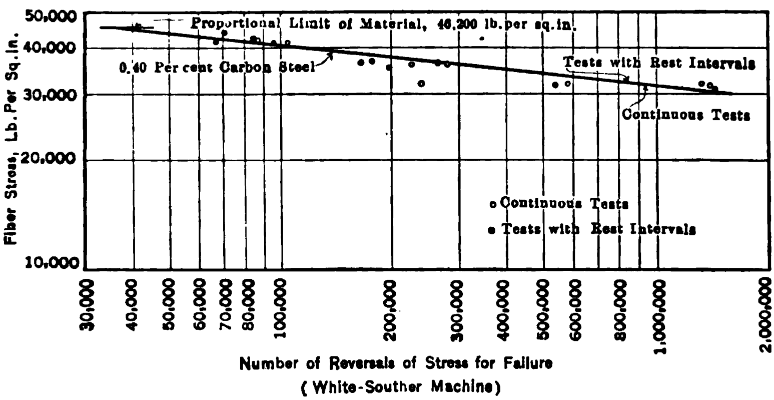


FIG. 8.—RESULTS OF FATIGUE TESTS OF 0.40 PER CENT. CARBON STEEL.

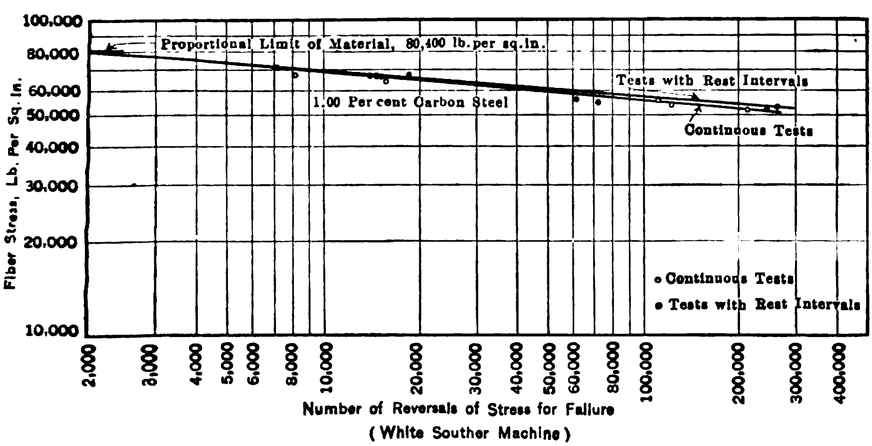


FIG. 9.—RESULTS OF FATIGUE TESTS OF 1 PER CENT. CARBON STEEL.

TABLE 3.—*Average Results for Static Tests on Effect of Rest on Fatigue Strength*

Kind of Steel	Number of Specimens	Proportional Limit, Lb. per Sq. In.	Ultimate Strength, Lb. per Sq. In.	Elongation in 2 in., Per Cent.	Reduction of Area, Per Cent.
Hot-rolled	4	33,200*	54,550	....	64.5
Tempered spring	4	147,900	224,400	3.0	18.2
Cold-rolled	2	40,200†	86,800	13.3	46.3
⅞-in. round structural steel bars	4	36,400	64,800	....	61.3
Nominal 0.20 per cent. carbon steel	17	40,300	64,300	38.8	63.4
Nominal 0.40 per cent. carbon steel	11	46,200	79,100	33.4	57.6
About 1.00 per cent. carbon steel	13	80,400	139,900	1.46	1.49

* A. S. T. M. Elastic Limit, 35,200 lb. per sq. in.
† A. S. T. M. Elastic Limit, 71,200 lb. per sq. in.

TABLE 4.—*Results of Fatigue Tests on Effect of Rest on Fatigue Strength*

Continuous to Failure			Resting 24 hr. at One-third and Two-thirds of Continuous Life		
Specimen Mark	Nominal Fiber Stress, Lb. per Sq. In. S	Number of Repetitions at Failure N	Specimen Mark	Nominal Fiber Stress, Lb. per Sq. In. S	Number of Repetitions at Failure N
Hot-rolled steel (Upton-Lewis machine)					
1S1	40,400	40,140	1R1	40,000	41,470
1S2	40,400	48,425	1R2	40,400	39,010
1S3	40,400	49,430	1R3	40,000	52,375
2S1	55,300	6,250	2R1	55,300	6,205
2S2	55,300	6,425	2R2	55,300	6,200
2S3	55,300	6,520	2R3	55,300	7,330
3S1	27,400	501,175	3R1	27,400	462,330
3S2	27,400	468,140	3R2	27,400	524,630
3S3	27,400	330,100	3R3	27,400	670,540
4S1	24,500	371,700	4R1	24,050	270,100
4S2	26,000	465,300	4R2	23,600	315,550
4S3	23,600	330,400	4R3	22,600	295,350
5S1	24,050	475,500	5R1	23,070	369,200
5S2	23,070	558,150	5R2	23,070	410,300
5S3	25,000	852,050	5R3	21,650	750,100
6S1	40,000	42,100	6R1	37,000	36,600
6S2	40,000	33,700	6R2	35,100	35,400
6S3	37,600	47,500	6R3	35,600	33,000

TABLE 4—(*Continued*)

Continuous to Failure			Resting 24 hr. at One-third and Two-thirds of Continuous Line		
Specimen Mark	Nominal Fiber Stress. Lb. per Sq. In S	Number of Repetitions at Failure N	Specimen Mark	Nominal Fiber Stress, Lb. per Sq. In. S	Number of Repetitions at Failure N
Tempered spring steel (Upton-Lewis machine)					
1S1	118,500	5,600	1R1	136,000	4,600
1S2	128,500	4,500	1R2	155,500	9,200
1S3	116,000	4,500	1R3	141,000	7,500
2S1	79,100	38,150	2R1	77,800	25,700
2S2	76,600	36,200	2R2	79,100	26,700
2S3	79,100	23,600	2R3	86,500	25,800
3S1	57,400	149,000	3R1	59,200	107,800
3S2	57,800	106,400	3R2	61,100	137,100
3S3	58,800	119,500	3R3	64,000	108,400
4S1	44,200	895,000	4R1	44,200	320,100
4S2	29,400*	178,800	4R2	44,200	347,500
4S3	28,200*	263,800	4R3	43,700	4,027,300
Cold-rolled steel (Upton-Lewis machine)					
1S1	62,500	18,200	1R1	66,100	13,400
1S2	58,700	25,550	1R2	66,100	14,800
1S3	62,500	16,900	1R3	66,100	14,000
2S1	80,800	4,900	2R1	84,400	4,400
2S2	80,800	8,150	2R2	84,400	5,060
2S3	79,000	4,200	2R3	84,400	5,340
3S1	42,200	115,800	3R1	34,900	92,750
3S2	41,300	71,200	3R2	38,500	77,900
3S3	42,200	50,150	3R3	40,400	49,400
⅞-in. round structural steel bars (White-Souther machine)					
1S1	27,700	1,240,000	4S1	26,850	14,465,400
	28,300	520,000		27,300	3,464,400
2S1	29,400	713,100	5S1	27,900	756,200
(Broke in grip)	29,400	713,100		27,100	1,275,200
3S1	27,900	779,300	9S1	32,000	117,700
	27,900	713,600		30,400	194,900
6S1	30,500	183,000	10S1	31,050	246,200
	30,400	859,700		31,000	352,900
7S1	30,800	308,000	11S1	31,700	247,900
	32,000	266,200		30,800	264,600
8S1	30,500	334,700	12S1	31,900	346,500
	31,000	334,800		31,200	365,000
1S2	37,300	77,500	8S2	34,100	147,700
	34,000	156,700		34,400	225,300
4S2	34,800	40,300	9S2	34,000	152,400
(Bent)	34,800	40,300		33,600	143,000
5S2	32,800	208,700	10S2	32,500	118,100
	32,800	164,600		33,000	118,200
6S2	32,500	95,400	11S2	33,500	118,500
	32,200	113,400		32,700	156,100
7S2	32,900	167,700			
	32,300	197,600			

* Machine out of order.

TABLE 4—(*Continued*)

Continuous to Failure			Resting 24 hr. at One-third and Two-thirds of Continuous Life		
Specimen Mark	Nominal Fiber Stress Lb. per Sq. In. S	Number of Repetitions at Failure N	Specimen Mark	Nominal Fiber Stress Lb. per Sq. In. S	Number of Repetitions at Failure N
Nominal 0.20 per cent. carbon steel (White-Souther machine)					
2–0	31,700	520,400	2–2	32,500	331,900
	32,300	477,200		32,000	203,000
2–1	32,150	501,200	2–3	32,900	458,700
	32,900	196,300		33,200	311,300
2–4	36,800	104,500	2–6	35,500	126,500
	36,000	110,500		36,100	64,300
2–5	37,000	69,500	2–7	38,000*	11,600 bent
	35,400	118,200		38,000*	11,600 bent
2–9	30,800	811,600	2–8	38,000*	4,200 bent
	29,800	667,500		38,000*	4,200 bent
2–A	29,300	720,300	2–B	30,600	782,100
	29,600	338,800		29,300	766,200
2–D	26,800	1,780,500	2–C	30,500	529,900
	26,000	207,174,900		29,800	426,600
2–E	26,650	3,348,500			
	27,900	526,593,800†Bent.			
Nominal 0.40 per cent. carbon steel (White-Souther machine)					
4–0–S	40,600	66,400	4–4–S	43,600*	2,400 bent
	41,500	95,100		41,700	66,800
4–2–S	41,500	103,800	4–9–S	43,300	84,300
	42,200	85,900		44,000	70,200
4–C–S	38,300*	36,900 bent	4–H–S	36,700	177,900
	28,300*	36,900 bent		36,500	266,100
4–F–S	36,400	279,700	4–I–S	35,600	198,800
	36,200	226,000		36,600	165,700
4–K–S	32,000	547,400	4–N–S	32,000	1,366,200
	31,900	1,398,200		31,600	1,422,900
4–M–S	32,100	589,100			
	32,200	240,000			
Nominal 1.00 per cent. carbon steel (White-Souther machine)					
4–1–H	68,500	8,200	4–5–H	67,500	18,200
	70,500	7,300		67,100	14,700
4–3–H	67,100	14,100	4–6–H	68,000	14,200
	64,000	15,600		67,500	14,900
4–7–H	54,500	122,300	4–A–H	53,600	260,100
	55,600	116,400		53,400	247,800
4–8–H	52,200	216,100	4–B–H	56,600	61,100
		1,699,700 Broke in chuck		54,900	71,800

* Estimated.

† Specimen bent, possibly accidentally.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Mental Tests in Industry*

PRESENTED BY ROBERT M. YERKES, WASHINGTON, D. C.

(New York Meeting, February, 1919)

THE following is a brief account of the methods of measuring intelligence especially prepared for use in the U. S. Army, of typical results, and of some of their immediately practical applications. It has been prepared for the assistance of army examiners and for the information of all who are interested in the relations of scientific placement to military efficiency.

Purpose of the Intelligence Tests

Under the direction of the Division of Psychology, Medical Department, and in accordance with provisions of War Department General Order No. 74, mental tests are given recruits during the 2-wk. detention period. These tests provide an immediate and reasonably dependable classification of the men according to general intelligence. Their specific purposes are to aid:

1. In the discovery of men whose superior intelligence suggests their consideration for advancement;
2. In the prompt selection and assignment to development battalions of men who are so inferior mentally that they are suited only for selected assignments;
3. In forming organizations of uniform mental strength where such uniformity is desired;
4. In forming organizations of superior mental strength where such superiority is demanded by the nature of the work to be performed;
5. In selecting suitable men for various army duties or for special training in colleges or technical schools;
6. In the early formation of training groups within regiment or battery in order that each man may receive instruction and drill according to his ability to profit thereby;

* Published with the approval of the Surgeon General of the Army, from the Division of Psychology, Medical Department, Major Robert M. Yerkes, Chief. This article, in slightly different form, was printed in November, 1918, by the National Research Council.

7. In the early recognition of the mentally slow as contrasted with the stubborn or disobedient;

8. In the discovery of men whose low-grade intelligence renders them either a burden or a menace to the service.

Nature of Tests

The tests were prepared by a committee of the American Psychological Association and of the National Research Council. Before being ordered into general use they were thoroughly tried out in four National Army Cantonments. From time to time they have been revised to increase their practical usefulness. Up to January 1, 1919, approximately one million seven hundred thousand men had been tested. Three systems of test are now in use:

1. *Alpha.*—This is a group test for men who read and write English. It requires only 50 min., and can be given to groups as large as 500. The test material is so arranged that each of its 212 questions may be answered without writing, merely by underlining, crossing out, or checking. The papers are later scored by means of stencils, so that nothing is left to the personal judgment of those who do the scoring. The mental rating which results is therefore wholly objective.

2. *Beta.*—This is a group test for foreigners and illiterates. It may be given to groups of from 75 to 300 and requires approximately 50 min. Success in Beta does not depend on knowledge of English, as the instructions are given by pantomime and demonstration. Like Alpha, it measures general intelligence, but does so through the use of concrete or picture material instead of by the use of printed language. It also is scored by stencils, and yields an objective rating.

3. *Individual Tests.*—Three forms of individual test are used: The Yerkes-Bridges Point Scale, the Stanford-Binet Scale, and the Performance Scale. An individual test requires from 15 to 50 min. The instructions for the Performance Scale are given by means of gestures and demonstrations, and a high score may be earned in it by an intelligent recruit who does not know a word of English.

All enlisted men are given either Alpha or Beta according to their degree of literacy. Those who fail in Alpha are given Beta, and those who fail to pass in Beta are given an individual test. As a result of the tests, each man is rated as A, B, C+, C, C−, D, D−, or E. The letter ratings are reported to the Interviewing Section of the Personnel Office, and are there copied on the qualification cards (in the square marked Intelligence). The psychological report, after the grades have been copied on the qualification cards, is forwarded from the Interviewing Section to the Mustering Section of the Personnel Office, where each soldier's letter rating is copied on the second page of his service

record. A copy of the psychological report is also sent by the psychological examiner to the company commander, who uses it in the organization of his company. In some camps, the entering of intelligence grades on service records has been left to company commanders, but accuracy and uniformity is secured by having these grades entered in the Mustering Section of the Personnel Office when the service records are being started.

The psychological staff in a camp is ordinarily able to test 2000 men per day and to report the ratings to the Personnel Office within 24 hr. Personnel adjutants coöperate in arranging the schedule of psychological examinations so as to secure from them maximum value.

Explanation of Letter Ratings

The rating a man earns furnishes a fairly reliable index of his ability to learn, to think quickly and accurately, to analyze a situation, to maintain a state of mental alertness, and to comprehend and follow instructions. The score is little influenced by schooling; some of the highest records have been made by men who had not completed the eighth grade. The meaning of the letter ratings is as follows:

A. Very Superior Intelligence.—This grade is ordinarily earned by only 4 or 5 per cent. of a draft quota. The A group is composed of men of marked intellectuality. A men are of high-officer type when they are also endowed with leadership and other necessary qualities.

B. Superior Intelligence.—B intelligence is superior but less exceptional than that represented by A. The rating B is obtained by eight to ten soldiers out of a hundred. The group contains many men of the commissioned-officer type and a large amount of non-commissioned officer material.

C+. High Average Intelligence.—This group includes 15 to 18 per cent. of all soldiers. It contains a large amount of non-commissioned officer material with occasionally a man whose leadership and power to command fit him for commissioned rank.

C. Average Intelligence.—Includes about 25 per cent. of soldiers. Excellent private type with a certain amount of fair non-commissioned officer material.

C−. Low Average Intelligence.—Includes about 20 per cent. While below average in intelligence, *C−* men are usually good privates and satisfactory in work of routine nature.

D. Inferior Intelligence.—Includes about 15 per cent. of soldiers. *D* men are likely to be fair soldiers, but they are usually slow in learning and rarely go above the rank of private. They are short on initiative and so require more than the usual amount of supervision. Many of them are illiterate or foreign.

D− and E. Very Inferior Intelligence.—This group is divided into two classes: D− men, who are very inferior in intelligence but are considered fit for regular service, and E men, those whose mental inferiority justifies their recommendation for development battalion, special-service organization, rejection, or discharge. The majority of D− and E men are below 10 years in mental age.

The immense contrast between A and D− intelligence is shown by the fact that men of A intelligence have the ability to make a superior record in college or university, while D− men are of such inferior mentality that they are rarely able to go beyond the third or fourth grade of the elementary school, however long they attend. Many of them are of the moron grade of feeble-mindedness. B intelligence is capable of making an average record in college, C+ intelligence cannot do so well, while mentality of the C grade is rarely capable of finishing a high-school course.

Directions for the Use of Intelligence Ratings

In using the intelligence ratings the following points should be borne in mind:

1. The mental tests are not intended to replace other methods of judging a man's value to the service. It would be a mistake to assume that they tell us infallibly what kind of soldier a man will make. They merely help to do this by measuring one important element in a soldier's equipment, namely, intelligence. They do not measure loyalty, bravery, power to command, or the emotional traits that make a man "carry on." However, in the long run these qualities are far more likely to be found in men of superior intelligence than in men who are intellectually inferior. Intelligence is probably the most important single factor in soldier efficiency, apart from physical fitness.

2. Commissioned-officer material is found chiefly in the A and B groups, although, of course, not all high-score men have the other qualifications necessary for officers. Men below C+ should not be accepted as students in Officers' Training Schools unless they possess exceptional power of leadership and ability to command.

3. Since more than one-fourth of the enlisted men rate as high as C+, there is rarely justification for going below this grade in choosing non-commissioned officers. This is especially the case in view of the likelihood of promotion from non-commissioned to commissioned grade. Even apart from considerations of promotion, it is desirable to avoid the appointment of mentally inferior men (below C) as non-commissioned officers. Several careful studies have shown that C− and D sergeants and corporals are extremely likely to be found unsatisfactory. The fact that a few make good does not justify the risk taken in their appointment.

4. Men below C+ are rarely equal to complicated paper work.

5. In selecting men for tasks of special responsibility, the preference should be given to those of highest intelligence rating who also have the other necessary qualifications. If they make good, they should be kept on the work or promoted; if they fail, they should be replaced by men next on the list. To aid in selecting men for occupational assignment, data have been gathered on the range of intelligence scores found in various occupations. This material has been placed in the hands of the Personnel Officers for use in making assignments. It is suggested that those men who have an intelligence rating above the average in an occupation should be the first to be assigned to meet requirements in that occupation. After that, men with lower ratings should be considered.

6. In making assignments from the depot brigade to permanent organizations, it is important to give each unit its proportion of superior, average, and inferior men. If this matter is left to chance, there will inevitably be weak links in the army chain. Exception to this rule should be made in favor of certain arms of the service which require more than the ordinary number of mentally superior men, *e. g.*, signal corps, machine gun, field artillery, and engineers. These organizations ordinarily have about twice the usual proportion of A and B men and very much less than the usual proportion of D and D− men.

The first two columns in the accompanying table illustrate the distribution of intelligence ratings typical of infantry regiments and also the extreme differences in the mental strength of organizations which are built up without regard to these ratings. The last column to the right shows a balanced distribution of intellectual strength which might have been made to each of these two regiments.

Typical Distribution of Intelligence Ratings in Infantry Regiments

Intelligence Rating	Interpretation	Two Actual Distributions: 1st Regt., Per Cent.	Two Actual Distributions: 2d Regt., Per Cent.	Balanced Distribution, Per Cent.
A	Very superior	1.0	6.0	3.5
B	Superior	3.0	12.0	7.5
C+	High average	7.0	20.0	13.5
C	Average	15.0	28.0	21.5
C−	Low average	25.0	19.0	22.0
D	Inferior	31.0	13.0	22.0
D−	Very inferior	18.0	2.0	10.0

Unless intelligence is wisely distributed certain companies which train much more slowly than others will delay the program of the regiment.

7. D and D— men are rarely suited for tasks which require special skill, resourcefulness or sustained alertness. It is also unsafe to expect D, D—, or E men to read or understand written directions.

8. Only high-score men should be selected for tasks which require quick learning or rapid adjustments.

9. It should not be supposed that men who receive the same mental rating are necessarily of equal military worth. A man's value to the service should not be judged by his intelligence alone.

10. The intelligence rating is one of the most important aids in the rapid sorting of the masses of men in the depot brigade. In no previous war has so much depended on the prompt and complete utilisation of the mental ability of the individual soldier. It is important, therefore, that the psychological ratings be regularly used as an aid in the selection, assignment, and classification of men.

Evidence that the Tests Measure Military Value

It has been thoroughly demonstrated that the intelligence ratings are useful in indicating a man's probable value to the service. The data on this matter presented in the accompanying diagrams are typical.

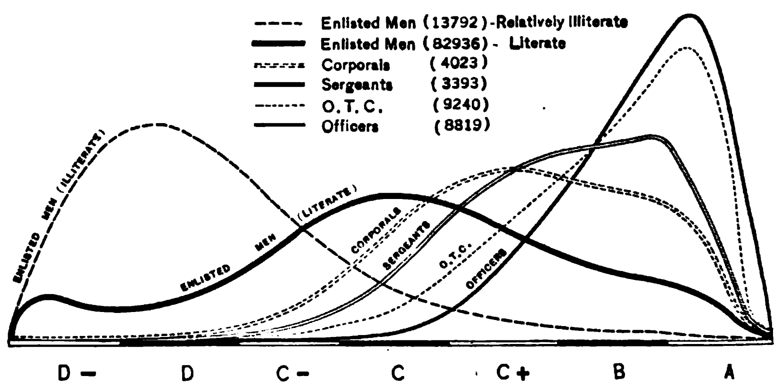


Fig. 1.—Distribution of intelligence ratings in typical army groups, showing value of tests in identification of officer material. Illiterate group given Beta; other groups, Alpha.

The psychological ratings have proved valuable not so much because they make a better classification than would come about in the course of time through natural selection, but chiefly because they greatly abbreviate this process by indicating immediately the groups in which suitable officer material will be found, and at the same time those men whose mental inferiority warrants their elimination from regular units in order to prevent retardation of training. Speed counts in a war that costs $50,000,000 per day. Fig. 1 shows the distribution of intelligence ratings in typical army groups.

Fig. 2 shows the results for three Officers' Training Schools, having a total enrollment of 1375. Note the rapid increase in elimination in grades below B. Of those above C+, 8.65 per cent. were eliminated; of those below C+, 58.27 per cent.

Fig. 3 shows the results for four Non-commissioned Officers' Training Schools, having a total enrollment of 1458. Note the rapid increase in elimination in the grades below C. Of those above C, 18.49 per cent. were eliminated; of those below C, 62.41 per cent.

In Fig. 4, note the striking intellectual contrast between those who have been selected as officer material and the men who have been designated as unteachable or of low military value.

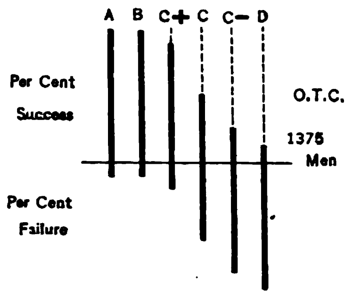


Fig. 2.—Success and failure in officers' training schools.

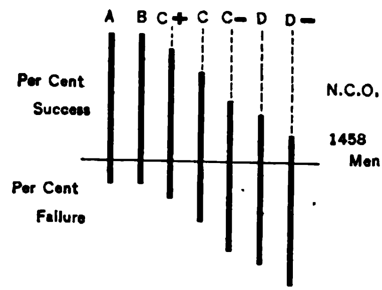


Fig. 3.—Success and failure in non-commissioned officers' training schools.

The men of Fig. 5 numbered 374. They were classified in five groups by their officers on the basis of general value to the service. The men were selected from 12 different companies, on the basis of officers' knowledge of them. Approximately 30 men in each company were ranked in serial order from best to poorest by a superior officer. This rank order for each company was then correlated with the rank order furnished by the tests. In 7 of the 12 companies the correlations were between 0.64 and 0.75. The average correlation for the 12 companies was 0.536. These correlations are high, considering the large number of factors which may enter to determine a man's value to the service.

Explanation of Fig. 6

Commanding officers of 10 different organizations, representing various arms in a camp, were asked to designate: The most efficient men in the organization; men of average value; men so inferior that they were barely able to perform their duties. The officers of these organizations had been with their men from 6 to 12 mo. and knew them exceptionally well. The total number of men rated was 965, about equally divided among best, average, and poorest. After the officers' ratings

had been made, the men were given the psychological test. Comparison of test results with officers' ratings showed:

1. That the average score of the best group was approximately twice as high as the average score of the poorest group.

2. That of men testing below C−, 70 per cent. were classed as poorest and only 4.4 per cent. as best.

3. That of men testing above C+, 15 per cent. were classed as poorest and 55.5 per cent. as best.

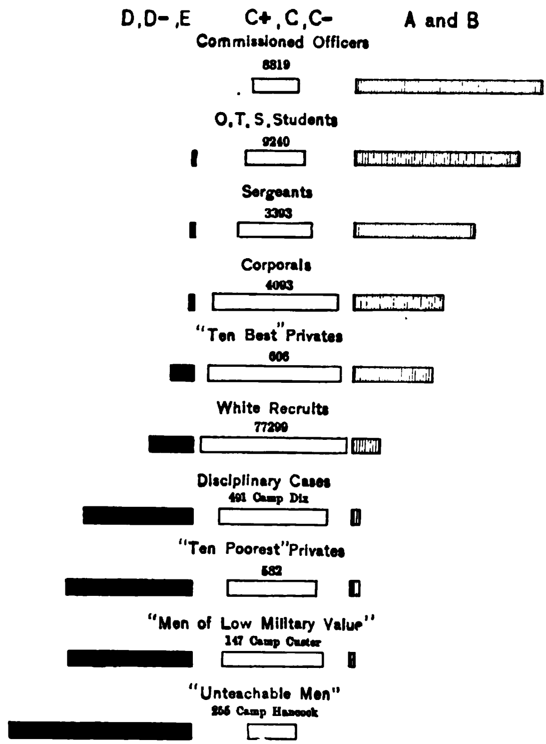


FIG. 4.—PROPORTION OF LOW, AVERAGE AND HIGH-GRADE MEN IN TYPICAL GROUPS.

4. That the man who tests above C+ is about 14 times as likely to be classed best as the man who tests below C−.

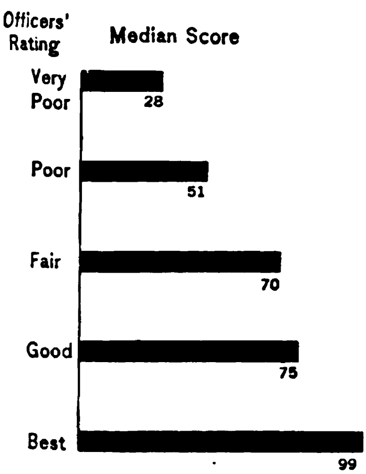
5. That the per cent. classed as best in the various groups increased steadily from 0 per cent. in D− to 57.7 per cent. in A, while the per cent. classed as poorest decreased steadily from 80 per cent. in D− to 11.5 per cent. in A. Considering that low military value may be due to many things besides inferior intelligence, the above findings are very significant.

In an infantry regiment of another camp were 765 men (regulars) who had been with their officers for several months. The company

commanders were asked to rate these men as 1, 2, 3, 4, or 5 according to practical soldier value, 1 being highest and 5 lowest. The men were then tested, with the following results:

1. Of 76 men who earned the grade A or B, none was rated 5 and only 9 were rated 3 or 4.

2. Of 238 D and D− men, only one received the rating 1, and only 7 received a rating of 2.



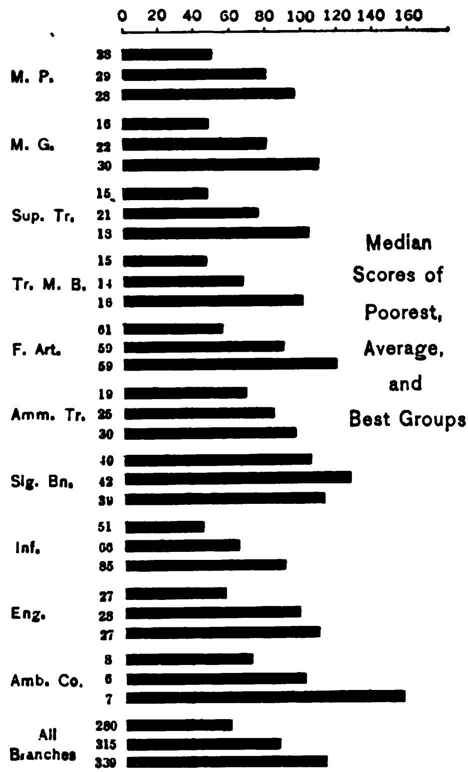


Fig. 5. Fig. 6.

Fig. 5.—Median intelligence scores (by points) of groups designated as best, good, fair, poor, and very poor in military value.

Fig. 6.—Median intelligence scores (by points) of poorest, average, and best men in various arms of service.

3. Psychological ratings and ratings of company commanders were identical in 49.5 per cent. of all cases. There was agreement within one step in 88.4 per cent. of cases, and disagreement of more than two steps in only 0.7 per cent. of cases.

Sixty company commanders were asked to name ten best and ten poorest privates. Of the poorest, 57.5 per cent. graded D− or D, and less than 3 per cent. A or B, see Fig. 7. The data show that a man above C+ is from 8 to 12 times as likely to be best as to be poorest; and that a

man below C— is from 6 to 10 times as likely to be poorest as to be best. Intelligence seems to be the most important single factor in determining a soldier's value to the service.

In another camp 221 inapt men of a negro pioneer infantry regiment were referred by their commanding officers for special psychological examination. Of the 221, nearly half (109) were found to have a mental age of 7 years or less. These men had been transferred from camps

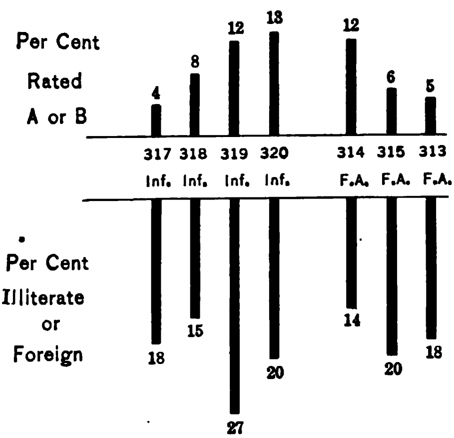


FIG. 12.

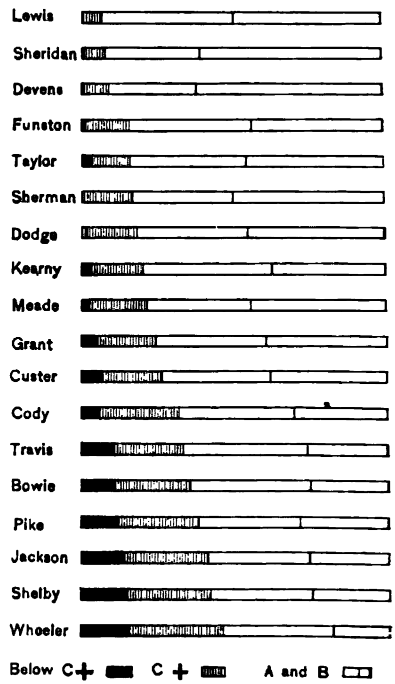


FIG. 13.

FIG. 12.—INEQUALITY OF REGIMENTS.
FIG. 13.—INEQUALITY OF MENTAL STRENGTH IN 18 OFFICERS' TRAINING SCHOOLS, 4TH SERIES (TOTAL ENROLLMENT 9,240).

where there were no psychological examiners, consequently they had not been examined previously. Such data illustrate the danger incurred in building units without regard to mental ratings. See also Fig. 8.

In a unit about to go overseas 306 men were designated by their commanding officers as unfit for overseas service. These were referred for psychological examination, with the result that 90 per cent. were found to be mentally 10 years or lower, and 80 per cent. 9 years or lower, see Fig. 9.

Mental tests reveal the weak links in the army chain. As a result of findings like those illustrated by Figs. 10, 11, and 12, the intelligence ratings are being widely used as a basis for equalizing or balancing the

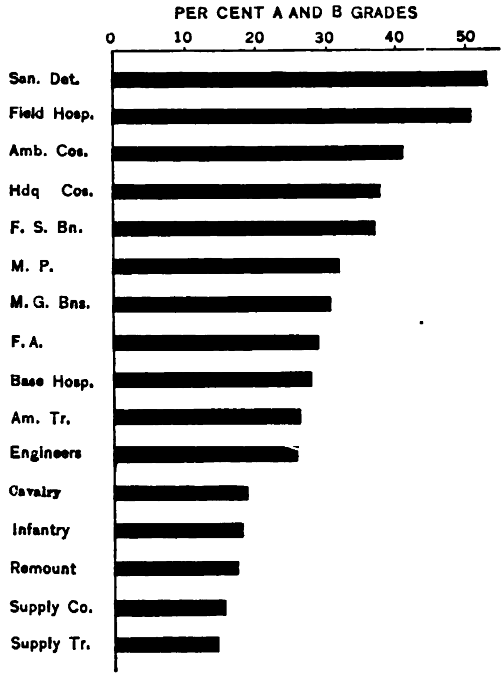


FIG. 14.—COMPARISON OF ARMS OF SERVICE.

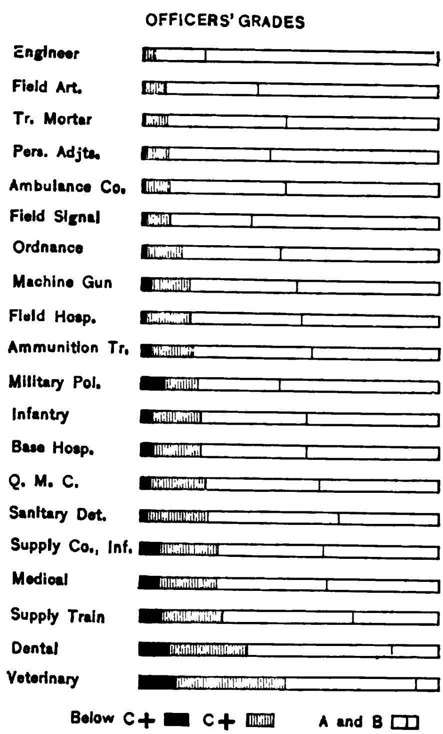


FIG. 15.—PROPORTION OF HIGH AND LOW GRADES IN VARIOUS OFFICER GROUPS.

mental strength of units. As many as 25,000 men have been permanently assigned to a division in a few hours on the basis of intelligence scores and tables of occupational needs. In the engineering regiment shown in Fig. 11, a redistribution of men was made on the basis of the evidence

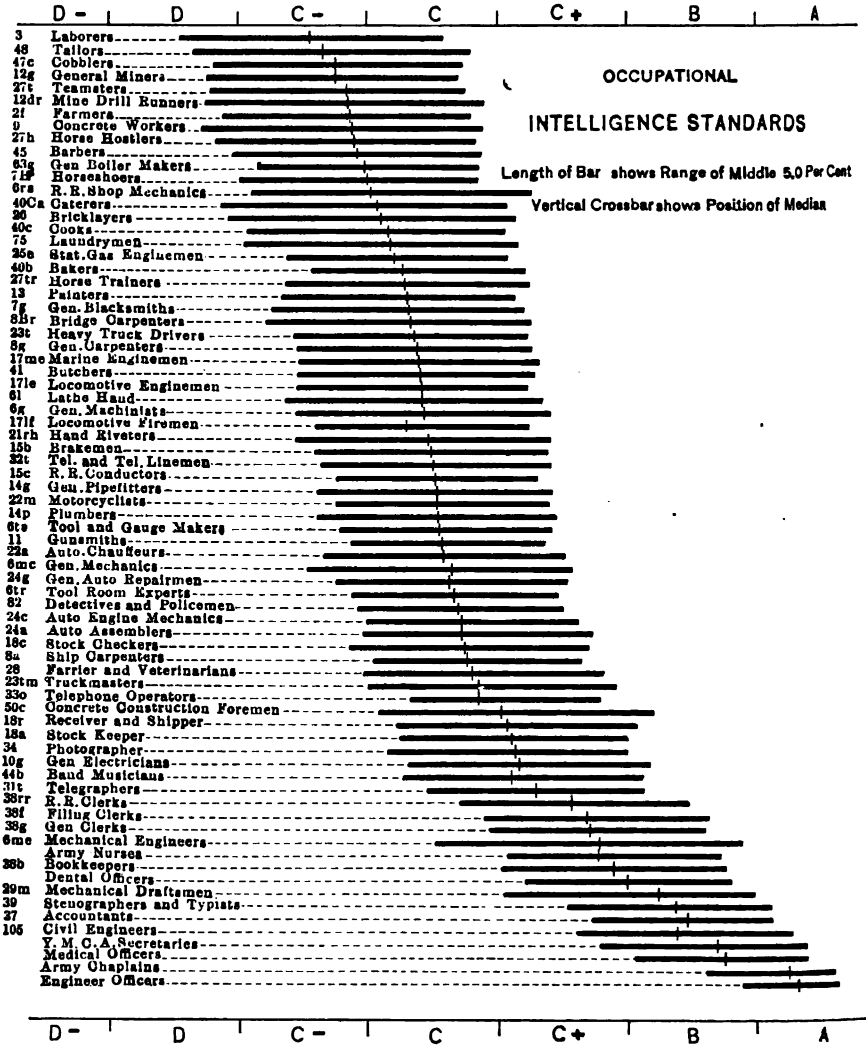


FIG. 16.—OCCUPATIONAL INTELLIGENCE STANDARDS.

submitted by the psychological examiners. One year later an officer of this regiment reported that, in the opinion of the officers of the regiment, its efficiency had been increased 100 per cent.

In replacement units interesting experiments in training are in progress. Often the A and B recruits are placed in one group, the C+,

C, and C− men in another group, and the D and D− men in a third group. By such classification, it has been found possible to secure greater speed in training. High-grade men are not delayed by the inapt, and low-grade recruits are given specially qualified instructors, special forms of drill, and various kinds of individual attention. Thus all recruits progress as rapidly as their individual ability permits.

The proportion of A grades in the schools shown in Fig. 13 varied from 16.6 to 62.4 per cent.; the proportion of A and B grades combined from 48.9 to 93.6 per cent.; and the proportion below C+ from 0 to 17.9 per cent.

Fig. 14 shows the per cent. of enlisted men grading A or B in various arms of the 34th division. Different arms of the service do not require the same mental strength. Experience shows that few men of D or D− grade can be safely used in field artillery, machine-gun battalions, or field signal battalions.

The proportion of A grades, in various officer groups, as shown in Fig. 15, varies from 8 to 79 per cent.; the proportion of A and B grades combined, from 52 to 96 per cent.; and the proportion below B, from 4 to 48 per cent. Note the remarkably high ratings of engineer officers.

In Fig. 16, the bar shows range of middle 50 per cent. The vertical cross bar shows position of median. The figure is based on data for approximately 36,500 men. Numbers at extreme left are key numbers of occupations. Data are taken from soldiers' qualification cards. These data, although inadequate for practical purposes and relating to the army alone, suggest the possibility of securing intelligence specifications for important groups of occupations.

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Manganese Bronze*

BY P. E. MCKINNEY,† WASHINGTON, D. C.

(New York Meeting, February, 1919)

DEVELOPMENTS in engineering during the past decade, particularly as applied to marine construction, mining machinery and other purposes in which corrosion offers a serious problem, have created a large demand for a non-ferrous metal highly resistant to corrosion and at the same time useful in general construction work as a substitute for steel without materially decreasing the factor of safety or increasing the weight of the various parts over that ordinarily used in the case of mild steel.

To obtain the combination of desired properties many compositions have been proposed and used with excellent success, but at the present time probably the most popular and most widely used combination is the non-ferrous alloy commonly called manganese bronze. This is nothing more than a high brass to which have been added, by the proper method of alloying, comparatively small percentages of aluminum, iron, or manganese with the definite purpose in view of strengthening the alloy and rendering it more dense and close-grained than the average yellow-brass casting.

In the manufacture of manganese bronze a great deal has been said about the importance of using only the highest grades of raw material and the beneficial or detrimental effects, as the case may be, of various impurities, as well as the importance of adding the ingredients according to various formulas proposed; but in most of these cases the literature on the subject has dealt principally with the manufacture of this alloy from virgin metals and raw materials of the highest purity. It is the purpose of this paper to deal particularly with the possibilities that lie in the proper development of methods for manufacturing such an alloy by more economical methods than those which have usually been discussed in other literature on the subject. Shortages have recently existed in raw materials needed for many products entering into the various branches of engineering work, particularly the non-ferrous metals, and during the next few years of reconstruction the country will be flooded with many

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† Chemist and Metallurgist of the Naval Gun Factory, U. S. Navy Yard.

byproducts and much scrap resulting from the extensive operations carried on during the period of the war, during which time scrap and byproducts could not be handled in sufficient volume to effect rapid production. These facts constitute conditions that make a project looking toward the efficient utilization of such materials well worth while.

When manufacturing manganese bronze or similar alloys from raw materials there is intentionally added a percentage of iron, which is generally conceded to be one of the very objectionable impurities in nonferrous scrap, in addition to which aluminum and manganese are added, and sometimes tin in small quantities, all of which if present in the virgin metals ordinarily used in nonferrous foundry practice would be considered detrimental impurities. The composition of the average manganese bronze is as follows:

	Per Cent.
Copper	57.00 to 59.00
Zinc	38.00 to 40.00
Iron, manganese, aluminum, tin	0.25 to 1.00
Lead	0.10 to 0.50

which composition shows rather clearly that there is no necessity for the use of high-grade raw materials, provided methods of manufacture can be devised to produce the proper refinement of the finished product, as the ordinary impurities encountered in non-ferrous materials offer no serious obstacles when the same elements must be added in considerable percentages to effect the desired composition.

In the manufacture of manganese bronze it has been found possible to utilize what would ordinarily be termed material of very low grade, such as skimmings from the foundry, particularly skimmings and dross ordinarily recovered from brass rolling mills or cartridge-case plants, zinc dross recovered from galvanizing plants, aluminum turnings that are ordinarily unrecoverable without serious loss and deterioration of the product due to oxidation, etc., and other byproducts and scrap metals that ordinarily are not usable as remelting scrap in foundry practice. The manufacture of high-grade manganese bronze from materials of this class, however, cannot be attempted in crucible furnaces, or practiced only on a comparatively small scale, as there is required a reverberatory or other furnace in which it is possible to accumulate a bath of considerable volume and in which the charge of metal can be worked in the same manner as in other refining processes producing on a large scale in open-flame furnaces. The idea is to so compound the various materials available as to cause one to react with the other to the mutual benefit of all the ingredients going into the charge.

A typical charge for operating a reverberatory furnace in the manufacture of manganese bronze is as follows:

	Pounds
Yellow-brass machine-shop turnings	1250
Zinc dross from galvanizing plant	400
Aluminum turnings	30
Recovered scrap zinc	400
Dross and skimmings from billet and slab plant	2000
Foundry-floor scrap and skimmings	650
Hardener made by melting scrap copper and manganese in equal proportions	250
Charcoal	75
Common salt	80

With a knowledge of the general chemical composition of each ingredient going into the charge it is easy to produce a manganese bronze that will have the desired composition and will require no other treatment than, possibly, the addition of a little zinc when remelting for casting purposes.

When handling a charge such as that just shown, advantage is taken of impurities, such as the iron existing in the zinc dross, the small percentages of tin in the machine-shop turnings, etc., in figuring the final desired analysis of the alloy. It is a well-known fact that such materials as zinc dross and foundry skimmings, both of which are full of dirt and oxides, cannot be recovered in a usable condition when melted separately in crucibles or by any of the ordinary methods of melting material, without an excessive loss due to volatilization. But when the well-known reactions occurring in the manufacture of old-fashioned calamine brass are taken into consideration, it can be seen how the combination of zinc dross, brass skimmings, and other highly oxidized materials melted in contact with charcoal will produce an alloy about as well deoxidized as the average high-zinc brass. Contact, while in a molten or semi-molten state, of metallic copper and partly oxidized zinc in the presence of charcoal develops a condition extremely conducive to a thorough deoxidation and alloying of all the metallic ingredients. This reaction, together with the well-known deoxidizing effects of aluminum, manganese and iron, which are part of the charge, contributes to the production of thoroughly deoxidized and dense material. Salt is used as a flux on account of its excellent properties for gathering and fluxing off the dirt from the charge, the oxides of iron, manganese, etc., and the reduction of any copper oxides passing from the bath into the slag.

In charging the furnace, it is the usual practice to place the manganese hardener in the bottom of the furnace and on top of it place the cartridge-case dross and zinc dross with a layer of charcoal, after which the foundry skimmings and turnings are added and the charge is melted, with occasional rabbling to clear the metal and bring all the ingredients into intimate contact. When the bath is melted, the aluminum scrap is added and the necessary zinc additions are made, after which the charge

is allowed to cool slightly in the furnace and is poured into ingots for remelting purposes, after analysis has been made to determine the necessity of adding zinc or otherwise correcting the composition by the mixture of several heats in order to obtain the desired composition.

The foregoing process carried out by a skilled melter will produce an alloy that is absolutely sound and homogeneous and capable of being cast in ordinary foundry practice in the same manner as any of the so-called high grades of manganese bronze, and will produce most excellent physical properties in the finished casting.

As instances of what can be obtained, the following results of tests are given. These tests were made on castings produced by the method described from initial charges of raw material practically identical with the typical charge given.

TABLE 1.—*Analyses of Ingots as Poured from Reverberatory Furnace*

	Copper, Per Cent.	Zinc, Per Cent.	Tin, Per Cent.	Lead, Per Cent.	Iron, Per Cent.	Aluminum, Per Cent.	Manganese, Per Cent.
Heat A....	57.95	39.08	0.35	0.42	0.83	0.59	0.77
Heat B....	57.18	39.54	0.51	0.34	1.04	0.48	0.91

TABLE 2.—*Physical Values Obtained on Sand Castings Poured from Remelt of Ingots without Additions*

	Tensile Strength, Lb. per Sq. In.	Yield Point, Lb. per Sq. In.	Elongation, Per Cent.
Heat A........................	67,700	46,300	22.1
Heat B........................	72,100	50,400	21.0

TABLE 3.—*Physical Tests of Sand Castings Made from Manganese Bronze Produced by Process Described*

Tensile Strength, Lb. per Sq. In.	Yield Point, Lb. per Sq. In.	Elongation, Per Cent.
67,300	45,800	29.9
66,400	37,400	30.9
67,700	41,200	24.5
72,200	34,100	24.5
67,900	33,900	28.1
72,600	36,700	23.4

In addition to the excellent properties shown in the tensile tests, the material corresponds in every other physical respect to so-called high-grade manganese bronze produced from virgin metals, has a fine uniform

fracture with a tendency to silky grain in many cases and shows toughness and resiliency equal to any other grades of manganese bronze examined.

Some objections may be raised to the use of byproducts and scrap material in the manufacture of manganese bronze because the lead content of some of these byproducts is quite high and will introduce into the alloy quantities of lead higher than are desired. It is believed, however, that the results of tests made from time to time on manganese bronze, containing in some cases a considerable percentage of lead, have shown conclusively that lead within reasonable limits is not detrimental. No concrete cases have as yet been cited in which, other things being equal, lead under 0.75 per cent. has shown seriously detrimental effects on the alloy. All the samples on which physical tests are given contained percentages of lead ranging from 0.25 to 0.50 per cent., yet none of them show in the test results any detrimental effects due to the presence of this so-called impurity. It is believed that the tolerance of a slightly higher content of lead in specifications for manganese bronze would, in general, serve admirably as a conservation measure for high-grade virgin material and offer excellent opportunities for the utilization of many metallurgical byproducts that at the present time constitute practically useless material.

The results obtained after about 3 years of operation under the process described have shown rather conclusively that the alloy commonly known as manganese bronze can be produced without resorting to the use of high-grade virgin materials with the addition of what would ordinarily be termed detrimental impurities, by the simple application of some of the well-known laws of metallurgy.

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Metals and Alloys from a Colloid-chemical Viewpoint

BY JEROME ALEXANDER,* M. SC., NEW YORK, N. Y.

(New York Meeting, February, 1919)

It is an outstanding fact of Nature that many of the practical properties of substances are dependent, not on their ultimate chemical composition, but on the kind and degree of aggregation of their constituent particles. Thus, a granite boulder is unmoved by wind or water, but if reduced to a fine dust it will be blown about by the wind and washed away by the rain. Carbon in one crystalline state of aggregation (diamond) is the hardest known substance, whereas in another crystalline state (graphite) it is so soft that it is used as a lubricant. Laying too much stress on the mere chemical analysis of substances is apt to obscure the fact that the nature of the aggregation of their particles is always a factor of importance, and sometimes the most important factor.

Colloid chemistry deals with matter in a very fine state of subdivision; its sphere begins with particles just a little smaller than a wave length of light and extends down until they blend into molecular dimensions. With particles of this size, such phenomena as surface tension and adsorption, which depend on the development of free surface, become enormously magnified. Thus a cube of 1 cm. edge has a surface of only 6 sq. cm.; but if it is reduced to colloidal dimensions by being cut up into cubes each having an edge of 0.01 μ (0.00001 mm.), it will yield one million, million, million (1,000,000,000,000,000,000) such cubes, having a combined area of 600 sq. m., or 21,274 sq. ft. The tiny force with which a drop of rain clings to the window pane becomes a factor to be reckoned with, if the surface involved is increased millions of times.

From the colloid-chemical viewpoint, metals, and alloys may be regarded as jellies or sponge-like structures, the viscosity or stiffness of which at ordinary temperatures is exceedingly great; and like all jellies their properties are dependent on the composition and degree of dispersion of their constituent phases. These, in turn, depend on chemical composition, mutual solubility, speed of chilling, subsequent mechanical and heat treatment, etc In fact, in preparing metals and

* Treasurer, National Gum & Mica Co.; Chairman, Special Committee on Colloids, Div. Chem. and Chem. Tech., National Research Council.

alloys for practical use, we remove undesirable constituents (as in the conversion of pig iron into steel), add desirable constituents (as in case-hardening or making alloy steels), or control the composition or particle size of the phases by chilling, rolling, or tempering.

It is a matter of importance which is the dispersed phase and which is the dispersing phase. For example, cream is an emulsion or dispersion of fat in water and wets paper, whereas butter is a dispersion of water in fat and greases paper. While I have not yet examined the experimental facts in the case of metals, it seems probable that the relative surface tensions of the phases toward each other are important factors in determining the constitution of the matrix or dispersion medium, and in determining which substances shall constitute the dispersed phases. Substances that lower surface tension tend to collect at the interfaces and produce in the matrix, as well as in the dispersed phases, a fine degree of subdivision. Thus, according to Putz, the predominant effect of vanadium in steel is to decrease the size of the ferrite grains and make the material harder; it renders the ordinary structure due to pearlite fine-grained and homogeneous.

I believe that the application of the ultramicroscope to the study of the minute structure of metals will reveal much that is of interest. The great difficulty is in preparing sections of sufficient tenuity for examination. One means of preparing such thin metallic films was devised by Faraday, who floated gold leaf upon dilute cyanide solutions; and an intimation of what results may be obtained was given by Sir George Beilby in his Hurter Memorial Lecture entitled The Surface Structure of Solids.[1]

Colloids exert a powerful influence on crystallization. Thus plaster of Paris crystallized from pure water shows characteristic long interlacing crystals. The addition to the water of even 0.01 per cent. of gelatine delays the set and practically inhibits the crystallization, there being formed instead spherocrystals. With the addition of 0.5 per cent. of gelatine, the time of set was increased from 40 min. to 960 min. Most metals have inherently a powerful tendency to crystallize, which in many cases is strongly inhibited by various substances present in the melt; and since even small quantities may produce the result, it is obvious that they are in a very finely dispersed state, and in many cases, probably colloidal.

The change in dispersion of a substance with varying chemical composition of the dispersion medium may be illustrated by an experiment with ordinary soap, which dissolves in alcohol into a clear crystalloidally dispersed solution; even in the ultramicroscope no particles are visible. In water, however, soap forms a cloudy colloidal solution;

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[1] *Jnl.* Soc. Chem. Ind. (1903) **22**, 1166.

and if sufficient water is added to the alcoholic solution, a turbidity at once becomes manifest. If water is added to the slide under the ultramicroscope, the alcoholic solution literally explodes into millions of actively moving ultramicrons of colloidal dimensions. Another strong analogy to metals is exhibited by transparent soap. When quickly chilled, it shows very small ultramicrons, whereas when slowly cooled the ultramicrons are much larger and may make the soap cloudy. Still another analogy is found in gold ruby glass. When quickly cooled, this is colorless and shows no ultramicrons; but when reheated, the invisible nuclei of metallic gold grow into visibility in the ultramicroscope and the glass develops a color. If the colorless glass has been formed under conditions insuring the formation of a very large number of nuclei, the glass when reheated develops a large number of small ultramicrons, and the color is a rich ruby red. If the initial chilling has been too slow, the nuclei are too few and too large, and when the glass is reheated there are formed a relatively small number of large masses of metallic gold, which give the glass a violet or dirty blue color. In such spoiled ruby glass, the aggregations of gold may grow until they are visible to the naked eye.

From what has just been said we can easily understand that when metals are heated so as to reduce their viscosity sufficiently, their particles move to establish the tendencies toward aggregation that were arrested by the high viscosity consequent upon solidification. This accounts for most of the phenomena consequent upon tempering or annealing. Even at ordinary temperatures gold and lead diffuse into each other, but the motion of their particles is so slow that it is quite invisible in the microscope and can be determined only after a long lapse of time. In fact, a cork, if given sufficient time, will gradually float to the top of a barrel of tar or asphalt.

Finally we might mention the diffusion of gases into and through metals. The adsorption of gas is primarily a surface phenomenon. Particles within the mass of a phase are on all sides surrounded by particles of the same kind. Particles at the surface, however, have one side in contact with a different phase. The free surface or interface may thus become the seat of a residual attraction or surface affinity. This is exhibited by freshly cleaved sheets of mica, which adhere if promptly put together, but in a few moments this property is lost owing to the adsorption of atmospheric gases. If there is a diminution of attraction at an interface, fracture will preferentially follow such interface, as is evident in coarsely crystalline metals, for example.

In the case of finely dispersed metallic systems, with enormous free interfaces, the adsorption of gas may weaken the attraction between the particles and render the metal brittle. In the case of gases with

actively moving particles, the metal may be actually penetrated by the gas, as those who have to handle hydrogen know to their sorrow.

In conclusion, I must emphasize the fact that in Nature all transitions are gradual. Ordinary coarse suspensions pass imperceptibly into and through the colloidal zone to actual crystalloidal subdivision, or so-called "true solution." Sols pass so gradually into gels that we cannot point out the exact spot where one ends and the other begins; and there is no sharp line of demarcation between physics and chemistry, which are connected by a twilight zone of colloidal phenomena partaking of the nature of both.

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Shimer Case-hardening Process

BY JOSEPH W. RICHARDS,* SO. BETHLEHEM, PA.

(New York Meeting, February, 1919)

THERE are two essentially different types of case-hardening processes; that using a dry mixture in which the object to be case-hardened is packed and kept for the necessary time at the necessary temperature, and the "liquid" process, employing a bath of fused salts into which the object is immersed and which by immediate contact case-hardens the surface of the article. The Shimer process belongs to the second class, and was a war emergency invention.

Of the liquid melts used as baths, the most effective and most frequently used are melted potassium cyanide and melted sodium cyanide. These may be used either pure or mixed with salts that reduce the melting point and the percentage of cyanide present. The use of these baths since 1914 has met many commercial difficulties because of the high price and frequent commercial scarcity of the cyanide salts; at present sodium cyanide has practically entirely displaced potassium cyanide. Another trouble is the danger to the workmen handling the cyanide salts, which are extremely poisonous, and the annoying and poisonous vapors or gases given off in the workshop, unless an effective system of hoods and ventilation is provided, so as to prevent the gases from the baths mixing with the air of the room.

Porter W. Shimer, of Easton, Pa., has invented a substitute[1] for the bath of melted cyanides which case-hardens with equal or greater facility and effectiveness, gives off no poisonous vapors, and costs for chemicals materially less than the cyanide costs in the previously used baths. The process has been in use over a year in a large American works and the following statement embodies the results of practical experience in the use and operation of the process.

The Shimer liquid or melted bath consists of a mixture of easily fusible salts that do not possess case-hardening properties, into which is immersed fresh calcium cyanamide, which imparts to the bath case-hardening properties. The composition of the non-case-hardening salts appears rather immaterial. Good results have been obtained by using a mixture of sodium chloride, calcium chloride, and barium chloride in

* Professor of Metallurgy, Lehigh University.

[1] U. S. Patents 1279457 and 1279458, Sept. 17, 1918.

equal proportions by weight; also a mixture of one part sodium chloride to one part calcium chloride. Potassium chloride can replace the sodium chloride where the question of cost is not material, producing a very liquid bath when equal chemical parts of the two salts are used; that is, 58.5 parts of sodium chloride to 75.5 parts of potassium chloride. Alkaline carbonates or alkaline hydroxides have also been added to the bath material with advantage in some special cases.

The mixture of non-case-hardening salts is melted in an iron or steel pot suitable for case-hardening operations, and the calcium cyanamide is brought into contact with it, which may be accomplished in several ways. One very effective method is to place small lumps of the cyanamide in an iron basket, which is sunk to the bottom of the case-hardening pot. A lively evolution of gas soon takes place, the exact composition of which has not yet been fully determined. The bath quickly acquires case-hardening properties, which last as long as the evolution of gas continues. What the exact chemical reaction of the cyanamide upon the non-case-hardening salts is, to produce a melt that has excellent case-hardening properties, has not yet been determined; it would need thorough and arduous chemical investigation to precisely illuminate the rationale of the operation. The fact remains, however, that contact of the cyanamide with the other salts imparts to the liquid bath active case-hardening properties.

The active evolution of gas is a valuable feature of the process; it keeps the bath in circulation and thereby equalizes its temperature, it accelerates the heating and case-hardening of objects immersed in the bath, and finally it is an important indication to the workman that the bath is in working order, with active case-hardening properties.

In practice, the calcium cyanamide is immersed in the bath of melted salts and as soon as a lively evolution of gas is shown, the dipping in of articles and their case-hardening can be proceeded with. If the evolution of gas becomes too active, the cyanamide may be removed and case-hardening can be proceeded with for some time after this removal. When the case-hardening power of the bath decreases, the cyanamide may be re-immersed and the operation continued as before. If the cyanamide is in large fresh pieces and the evolution of gas is not too violent, the cyanamide may be left permanently in the bath until it has lost its power of imparting case-hardening properties to the melt, as is shown by the diminution of the evolution of gas. On removing this apparently exhausted material, the larger pieces may be broken, thus exposing fresh surfaces, and the material will be found to still retain active properties when re-immersed in the bath.

It has been found that the cyanamide is best used in lumps varying from the size of a walnut to the size of an egg. It should be in the fresh condition as it is taken from the furnace; that is, it should be kept hermet-

ically sealed until used. If fine powder is put into the bath, it is difficult to keep the powder immersed, and the frothing is voluminous and troublesome. If the cyanamide has been exposed to air, absorbing moisture and becoming oxidized, it causes violent frothing when immersed in the bath, which continues an inconveniently long time. If only such cyanamide is available, it may be mixed with pulverized hard pitch or with tar, and the mass coked at a red heat; this eliminates absorbed moisture and changes the structure from powder to a porous coke. Such porous coke is then used in the melted salts in exactly the way that has been described for solid lumps of fresh calcium cyanamide. Arrangements have been made with the manufacturers of calcium cyanamide to select high-grade cyanamide for the purposes of this process, and to transfer it directly from the furnace in lumps of desired size to air-tight containers, so that its use in the process will always be at a maximum efficiency.

The quantity of cyanamide immersed may vary according to the size of the bath and the shape, size, and character of the articles to be case-hardened. A bath may have immersed in it 5 per cent. of its weight of the fresh calcium cyanamide, or a corresponding quantity of the cyanamide coke, for ordinary work.

Upon removal from the bath, the case-hardened articles are quenched in a suitable cooling liquid as in ordinary case-hardening practice.

A careful estimate of the relative cost of running with the sodium cyanide at normal market prices and specially selected calcium cyanamide as described, extending over more than a month's work in a large plant, shows the cost of the bath material to be materially less when using calcium cyanamide than when using sodium cyanide, with the case-hardening done in an equally satisfactory manner, and with much more comfortable and healthful conditions to the workmen.

The question of the scientific basis of the process is being investigated by the inventor, and may form the subject for further communication to the Institute.

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Prevention of Illness Among Employees in Mines

BY A. J. LANZA,* M. D., WASHINGTON, D. C.

(New York Meeting, February, 1919)

THE prevention of illness among the employees of the mining industry is especially important in view of the importance of the industry, the unsettled conditions of labor, which emphasize the economic necessity for conservation of labor, and for humanitarian reasons. The burden of chronic illness is altogether unwarranted and unnecessary. If the industry is to maintain its labor supply in an efficient manner and keep the standard high, it is essential that it make every effort to keep its labor in good physical condition.

The basic principles underlying health conservation are the same for any industry, but they are here applied especially to the mining industry, and more particularly, perhaps, to metal mining, as it is with this phase of the industry that the writer is most familiar, and as it is conceded that metal mining presents more health hazards than coal mining.

The first step in the prevention of illness lies in securing employees who are in sound health and free from organic disease. I do not mean that all men who go underground should be physically perfect, but they should be free from organic defects of the heart, lungs, and other organs, or from anatomical defects that would markedly increase their liability to accident. The number of men working underground in mines in this country whose physical condition totally unfits them for such work presents a situation that should not be allowed to continue, and which I believe is not equalled in any other industry in the country. There is but one way to secure men who come up to the required standard, and that is by a thorough physical examination before employment. I am fully aware of the objections felt toward such a procedure by many employers and employees. There is much to be said on both sides, but to any one who is at all familiar with the mining industry as it is today in this country, and who approaches the matter with an unbiased mind, there can be absolutely no doubt as to the necessity for physical examination. As a purely logical proposition this is self-evident, but there remains the further necessity of placing physical examinations on such a

* U. S. Public Health Service. Chief, Division Industrial Hygiene and Medicine, Working Conditions Service, Dept. of Labor.

basis that they can be administered in a just and equitable manner free from the abuses and suspicions to which they have been subject in the past.

The best way of administering physical examinations in the mining industry would be to have them conducted by properly constituted authorities of the various States. That is, if John Jones wished to work as a miner, when he appeared at the employment office of the Smith Mining Co., he would have in his possession a certificate from the State authorities declaring him to be free from organic or other defects that should, in the natural order of events, bar him from underground work. Such a system would presuppose reciprocity among the mining States and a basic standard of physical fitness. It would be well within the province of the Federal Government to establish such a standard for adoption by the various States. This arrangement may seem idealistic and impractical, and it is offered here largely for the purpose of causing reflection and argument, but at the same time, unless the mining industry can put into effect a system that will be fair both to employer and employee and that will prevent obviously unfit men from working underground, it will be almost useless to make any other effort toward prevention of illness among employees. I believe that the time has come for the American Institute of Mining Engineers to consider seriously the necessity and the means of carrying out physical examinations and to take a definite stand.

The second requisite for the prevention of illness among employees is the maintenance of working conditions underground on a high plane of sanitation and efficiency so that illness arising from working conditions may be held to a decent minimum. The greatest need in the improvement of underground conditions is the elimination of dry drilling in hard-rock mines. The relationship between hard-rock dust and miners' consumption has been so clearly demonstrated that it is not subject to argument; suffice it to say that the efforts made in England and in British colonial possessions to deal with this evil have shown the possibilities of abating it, while in this country little has been attempted. As long as dry drilling is permitted in hard-rock mines, just so long will we have an inordinate amount of pulmonary disease among the miners. That this has worked an economic hardship on the industry, aside from its humanitarian features, and that it has been one of the causes of the better grades of mine labor leaving the industry, is apparent to any one familiar with the conditions, and it is hard to understand why the subject of dry drilling has received so little attention in this country. Dry-drilling apparatus may be as deadly as a machine gun, if somewhat slower, and its continued use in the mining industry is a matter of reproach. While it may be true that the water varieties are not as satisfactory as they might be, at least their improvement should receive serious consideration. It is incredible

that American ingenuity, which has produced the telephone, the telegraph, and the flying machine, should be unable to cope with the production of a water drill that would largely make impossible miners' consumption.

Conditions of ventilation and temperature underground are not what they should be and have never received the attention in metal mines that they have in coal mines. This is also a matter of prime economic importance because a greater amount of work can be done under conditions of proper ventilation and temperature than when there is poor ventilation and high temperature. While the latter may not cause specific illness, certainly they lower the vitality, lessen working ability, and predispose to many illnesses; if we are to have healthy miners we must so arrange it that they can work in places properly ventilated and not excessively hot. Mine ventilation is too complex a subject to be considered here, but the use of small fans with canvas tubing seems to offer a satisfactory and economical means of improving ventilation.

Proper toilet facilities underground are important as a health measure but vary so much according to the size and locality of the mine that they need not be gone into in detail here; besides, their principles are well understood.

The third requisite consists of adequate provision for medical and surgical service so that minor illnesses and injuries may be promptly treated and not become of major importance. In regard to accidents, "safety first" has become highly specialized and efficient; health service, if I may use this term, has not been developed to the same proportion. While many of the larger mining companies maintain first-class hospitals, the prevention of sickness among miners has not kept pace with the prevention of injury. It is just as feasible to distribute posters and other educational matter dealing with the proper care of common colds, constipation, and other minor troubles, which are forerunners of serious ailments, as it is to impress on the miners the necessity of having the smallest injury promptly attended to by the company doctor. There is need for a closer coöperation between the doctors and the miners in handling the minor ailments when they first appear. In former days the miner was an English-speaking person with all the advantages of a knowledge of the country and its institutions; at present underground workers are largely foreigners, and the employer must provide for their health during working hours and often in their homes if he desires to keep them on the job.

It is probable that the mining industry will always be hazardous to health and life as compared with other industries but at present it is needlessly so, because the wastage of human material can be prevented by securing physically fit labor, and by keeping its health unimpaired.

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Work of National Production Committee of U. S. Fuel Administration

BY JAMES B. NEALE,* B. A., MINERSVILLE, PA.

(New York Meeting, February, 1919)

FROM the beginning of its activities, the members of the National Production Committee have felt that the following points were essential to the success of its work: The operators must feel that their operations were not 100 per cent. efficient; that they should be courteous and fair in their treatment of their employees; and that they should set an example of hard work and patriotic interest in increased production.

Every move made must appeal to the sense of fairness of all parties concerned.

The men must feel that in working more faithfully, and consequently producing more coal, they are rendering a distinct service to their Government in the time of its great need. As the workers feel that greater efficiency on their part results only in greater profits to the operators, the advantage to the operator should be lost sight of, as far as possible, and the advantage to the Government in fighting the war emphasized.

Both operators and workers should know that the Government considered increased production an obligation, and opportunity for service, resting on both parties and not on the operators or the workers alone, and that both parties could very much better the efficiency of the pre-war period. Had the committee intimated that it thought the coal shortage was due entirely to the idleness and ineffieiency of the workers, its campaign would have failed, for the men would have resented the charge because only too frequently their efforts to produce more coal were thwarted by bad management; besides the operators would have lacked stimulus to better effort. On the other hand, had the impression been given that the committee thought that the coal shortage was due entirely to bad management, the operators would have resented the charge because only too frequently their efforts to produce more coal were thwarted by the idleness and inefficiency of the workers; and the workers, having been thus indirectly pronounced 100 per cent. efficient and patriotic, would have lacked stimulus to better effort.

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* Director of Production, U. S. Fuel Administration.

Method Adopted for Increasing Production

With these points in mind, the committee devised the following plan: A production manager was chosen for each of the twenty-eight large producing districts. For the most part these managers were nominated by the operators in each district and they became the centers of the production activities. At a large percentage of the mines production committees were formed, one at each mine. These committees consisted of six men—of whom three were appointed by the management and three were chosen by the workers—and worked under the direction of the production manager, who served as the umpire in case of division in the committee. The members of these committees were given certificates of appointment and badges and every effort was made to have them feel that their position was one of dignity and responsibility; that they represented the Government and were fortunate in having an opportunity to render special service to the Government during the war. Their duties were carefully defined in a letter which was broadly circulated. In the main these duties consisted in discussing ways to better the efficiency of the mine and its equipment and of the mine workers.

The members of the National Production Committee, in Washington, made every effort to protect mine labor from undue inroads by the selective draft, voluntary enlistment, munition plants, and other war activities. They looked carefully after the needs of the operators as to mine supplies and obtained proper priorities for such materials. They dealt with the railroads in reference to car supply and rendered valuable assistance to power plants selling electricity to the mines. Soldiers who had seen active service and could bring home to the workers the life in the trenches and their relation to it visited hundreds of mining camps and addressed the workmen. A great amount of material, such as posters, poems, etc., that it was thought would appeal to the men and arouse their patriotism, was distributed and personal letters were written to workers who made unusual records.

In many districts, the production managers established the daily tonnage necessary from each mine and had the local production committee accept it as the Government's requirement. This was one of the most stimulating features as it gave the men at the mine a definite goal and they felt that the standard was set by the Government and not by the operator, so the unwillingness to work hard for the operator's benefit was more or less lost. The net result was a very large increase in production.

During the five very active months the National Production Committee spent in Washington, the members came in close contact with hundreds of operators, miners' leaders, and mine workers. All were keenly interested in increased production and frankly expressed their

views as to the causes that impeded production and as to the steps that should be taken to increase it. We discussed what were called methods for increased production, but which were really methods of increasing the harmony and coöperation between employer and employee, which is the true basis on which increased production must be built.

Need of Stimulating Ambition in Workmen

There is undoubtedly throughout the world, as is evidenced by the rise and spread of Bolshevism, a feeling that the good things have not been evenly divided; that some persons have had too much and many others too little. This is true in theory but it is difficult of correction. Doubtless the unequal distribution of wealth is due to the unequal distribution of worth, and until worth is equally distributed there can be no permanent equal distribution of wealth. It seems essential, therefore, to make an earnest persistent effort to emphasize the need of worth and to do everything possible to stimulate it. The Bolsheviki are trying to distribute wealth on the basis of might and disaster can be the only result of the effort. Is not the promotion of worth the proper counter-irritant to Bolshevism?

We, operators, as the pace-setters in the coal industry, must do our part. Our workmen must be, much more than ever, a matter of deep concern to us. We must plan well and unselfishly for their general well being and must use every effort to stimulate them to greater efficiency as to labor and to higher ideals as to the proper use of their lives. There must be created an ambition for more comfortable homes, and better food and clothing for themselves, their wives, and their children. The education of their children also must become one of their main desires. Now, their dominating desire is more leisure; fewer hours at work is their goal and increased wages help them to attain it but at the expense of production. This ambition is disadvantageous both to the men and to the operators and the only way to relieve the conditions it produces is by creating new ambitions and aims. A man who needs $30 a week to live in his accustomed manner and who can earn $5 per day, will work six days a week. If his earning power is increased to $7.50 a day, he can earn the $30 a week necessary by working only four days, so there will be a tendency on his part to decrease his working days from six to four. This is uneconomical for all parties. By stimulating in the man higher aims and ideals, which will require more money for their satisfying, will not only increase his desire to work but will also tend to change his work into service. These aims and ideals will make him feel that his work is not merely dull toil but that it is an honorable means of enabling him to gratify his higher ambitions. The war has paved the way for this work on the part of the operators, for during the past 18 months, as

ested in the home, the school, the church, and all social activities, in fact, in everything going on in the community that has an influence on the lives of the people. Until now our thoughts have centered on material things, on mechanical devices, and along these lines we have made great progress; but we have paid little attention to the social, physical, and moral betterment of our employees. For the most part we have not tried to see that the boys entering our employ each year were better than the boys who entered the year before. We have given little thought to our workmen, excepting as workmen, and even then we have made no effort to teach them what we should. We have complained bitterly of their actions many times and yet have done little or nothing to better their environment and opportunity and to stimulate higher ambitions and ideals. We have engaged a young man as a fireboss, or a pitboss, and have said to ourselves "That young fellow is a comer. I'll make a real man of him." We should consider each one of our workmen a comer and try to make a man of him. All of this may sound theoretical and impracticable but it is not. It cannot be done in a day or in a year, but it can and must be done if the good things of this world are to be gradually and fairly divided on the basis of worth, and are not to be suddenly and unfairly divided on the basis of might. We, operators, are face to face with a condition that is exceedingly important and serious, and I believe we are strong enough to meet it in the proper way.

During the past 18 months the President of the United States, in his various addresses and messages, has set up a very high standard. He has given to the world high ideals and every effort must be made to live up to them. The great mass of the people feel, in a hazy way perhaps, that peace is going to bring to the world better conditions; that there will be a more equal division of this world's goods; and that brotherhood will become much more a fact than before. It will be a keen and dangerous disappointment if the President's ideals do not prevail in large measure.

Notes on Certain Ore Deposits of the Southwest

Discussion of the paper of W. TOVOTE, to be presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 142, October, 1918, p. 1599.

PHILIP D. WILSON,* Warren, Ariz. (written discussion†).—Mr. Tovote's idea of attempting to classify according to their broad geologic relations the ore deposits and prospects of the Southwest is an admirable one. Attempts have been made to evolve some comprehensive scheme of classification that would be of practical assistance in determining the possible value of prospects, but the ore deposits are too varied in type, form, genesis, and distribution to lend themselves readily to any definite, scientific pigeon-holing. The classification Mr. Tovote recommends, combining the age of the mineralization with the type of the rock supposed to be its source, is open to criticism even on the evidence he presents. The age of many deposits is not nor can be definitely determined because of the absence of sedimentary rocks in their vicinity. Furthermore, the character of the mineralizing solutions has, in a large majority of cases, no relation to the composition of the associated igneous rock. While the solutions may have originated in the same magma, they were usually a much later manifestation of it, often appearing after the intrusive rock had completely solidified and been subsequently crushed and fractured, and in many cases the chemical difference is very marked.

It is true that igneous activity in the Southwest is definitely related to certain geologic periods. The statement, however, that no ore deposits can unmistakably be referred to periods earlier than late Cretaceous is not supported by fact. The bonanza copper orebodies of the Jerome District are definitely pre-Cambrian. As suggested by J. R. Finlay,[1] they are probably post-Beltian or late Algonkian in age, perhaps related to the same great mountain-making period as the copper deposits in the Keweenawan series of Lake Superior and the Sudbury, Porcupine, and Cobalt deposits of Ontario. The proof that they are pre-Paleozoic may be summarized as follows:

1. The pre-Cambrian complex in which they occur is overlaid by a great thickness of Paleozoic sediments with the Tonto or Tapeats sandstone at their base. The only primary mineralization in these sediments is an economically unimportant one connected with very recent basalt.

2. In the United Verde Extension mine, the gossan over the great orebody extends to the old pre-Cambrian surface where it is directly

* Geologist, Calumet & Arizona Mining Co.

† Received Dec. 12, 1918.

[1] The Jerome District of Arizona. *Engng. & Min. Jnl.* (Sept. 28, 1918) **106**, 557.

overlaid by unmineralized Tapeats sandstone. This would further indicate that the oxidation and enrichment of this orebody was completed before the Tapeats sandstone was deposited.

3. In the United Verde mine, included fragments of sulfide ore are found in later andesite dikes that cut the orebodies but do not invade the Paleozoic sediments.

4. The characteristic dark, rusty, red color of the basal Tapeats sandstone is attributed, by F. L. Ransome,[2] to ferruginous gossan material from the pre-Cambrian pyrite deposits in the schist.

5. It is true, as Mr. Tovote states, that the pyritic deposits in the schist do not show the result of the regional metamorphism that the neighboring rock has undergone for the reason that they are later than the probable source of the ore, the United Verde diorite, which in turn is massive and shows none of the evidence of the stresses that have produced the schistose structure in the older complex. The diorite is definitely pre-Cambrian but very evidently much younger than the greenstone and quartz porphyry schists that it intrudes.

Besides the Jerome district, there are several of less importance in Arizona in which the ore deposits may be pretty certainly referred to the pre-Cambrian, notably the copper deposits in the Yavapai schist belt in the Bradshaw Mountains from Stoddard south to Canyon, and the many copper specularite deposits in the pre-Cambrian schist in the vicinity of the Bill Williams and Colorado rivers. It is not logical to include Bisbee, where the mineralization is definitely pre-Cretaceous in age, in the same group with younger Globe-Miami, Clifton-Morenci, Ray, and Chino deposits when the entire period of Cretaceous sedimentation intervenes. It obviously belongs to a distinct period of igneous and mountain-making activity. There is some reason to believe that the Cananea deposits are of the same age as those in Bisbee, although there is no positive means of determining it. There is reason to question the classification of the "Parker Cut-off" deposits in pre-Cambrian schist, such as the Clara Consolidated and the Planet, as Tertiary-andesitic. The original intrusions with which the ore is in places associated have been very thoroughly altered and sheared to amphibolite and Howland Bancroft,[3] in common with most other observers, has considered them and the associated mineralization as definitely pre-Cambrian.

It seems dangerous and of little practical advantage to correlate such dissimilar and widely separated deposits as the disseminated copper deposits of Pilares, Ajo, and Red Mountain with the silver-lead orebodies of Tombstone, the silver-zinc lead veins of Crown King, and the gold

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[2] Some Paleozoic Sections in Arizona and their Correlation. U. S. Geol. Sur. *Prof. Paper* 98-K (1916).

[3] Ore Deposits in Northern Yuma Co., Arizona. U. S. Geol. Sur. *Bull.* 451 (1911).

veins of Oatman. In some of these cases, the igneous rock that can be regarded as the source of the mineralization is uncertain or unknown while in the case of the Ajo deposit the rock is a monzonite porphyry with decidedly basic phases. In the latter example, the unimportance of chalcocite enrichment, one of Mr. Tovote's criteria, can readily be explained by the geologic history, climatic conditions, and mineralogy of the ore.

In connection with Mr. Tovote's classification according to geologic provinces, in which he assigns Jerome to the "Yavapai schist" province, it may be interesting to note that no Yavapai schist, as it is defined by Jaggar and Palache,[4] has been found in the Jerome district. The schist in Jerome is composed entirely of ancient intrusive and extrusive volcanic rocks, flows, and bedded tuffs, while the Yavapai schist is typically a fine-grained quartz muscovite of sedimentary variety, intruded by granitic rocks. Both are probably older than the belt rocks but evidently do not belong to the same series and cannot be correlated.

If the final test of any scheme of classification proposed is its practical value in simplifying and facilitating the estimation of the probable value of a mine or prospect offered for sale or development, it should be based upon those qualities that actually determine the value of the ore deposit. These factors are neither the age of the mineralization nor the character of associated igneous rock, but rather the form of the deposit, which Mr. Tovote dismisses with scant consideration. It is with the fact that a deposit is a large disseminated body or a narrow vein or a garnet contact type that a prospective purchaser is interested rather than that it is Tertiary rhyolitic or Mesozoic semi-acid.

A rough physiographic separation of Arizona into the three divisions of Mr. Ransome[5] and Mr. Finlay[5]—the plateau region of prevalent subsidence in the northeast, the desert region of relative uplift in the southwest, and the zone of stress, fracturing, and igneous activity between the two, characterized by the great parallel mountain ranges and containing most of the important ore deposits—is valuable in indicating the most likely place to look for valuable mines. But even this broad scheme is no infallible guide, for one of the really great mines of the State, the New Cornelia, and many less important ones are found in the isolated desert ranges.

In short, while Mr. Tovote's paper shows much thought and a wealth of close observation and the idea that prompted it is excellent, there is ground for criticism both of the fundamental scheme proposed, which is impracticable, and of the attempt to include in too small a compass so many deposits differing widely in age and character.

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[4] T. A. Jaggar, Jr. and Charles Palache: U. S. Geol. Sur. *Bradshaw Mountains Folio* (1905).

[5] *Op. cit.*

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First Year of Leaching by the New Cornelia Copper Co.

BY HENRY A. TOBELMANN,* B. S., AND JAMES A. POTTER,† AJO, ARIZ.

CONTENTS

INTRODUCTION

THE location, mode of occurrence of ore, and preliminary tests leading to the development of the present leaching process and the building of the present plant on the property of the New Cornelia Copper Co. at Ajo, have been described in previous papers presented to the Institute and in the discussions thereof.[1] It is sufficient to say that these tests began early in July, 1912, and were continued to the close of January, 1916; that small tests at Douglas were followed by the construction of a 1-ton plant at the mine; and this was followed by the operation of a 40-ton plant for 14 mo. In all about 15,000 T. of ore were treated experiment-

* Metallurgist, New Cornelia Copper Co.

† Superintendent of Leaching Plant, New Cornelia Copper Co.

[1] Stuart Croasdale: Leaching Experiments on the Ajo ores. *Trans.* (1914) **49**, 610.
Ira B. Joraleman: The Ajo Copper Mining District. *Trans.* (1914) **49**, 593.
L. D. Ricketts: Some Problems in Copper Leaching. *Trans.* (1915) **52**, 737.
H. W. Morse and H. A. Tobelmann: Leaching Tests at New Cornelia. *Trans.* (1916) **55**, 830.

ally during the period mentioned, and those intimately connected with the work came to the conclusion that the process finally developed was right in principle. Accordingly a 5000-ton plant has been constructed and in operation 1 year at the writing of this article. It is proposed here to describe the result of this year's work, the difficulties that have been encountered, and the steps taken to overcome them, and to give an opportunity for those interested to compare the results of the experiments that have been described with the actual operation of a large plant.

The plant was completed on May 1, 1917. The first charge of ore was finished on May 17, and by June 1 the great bulk of solutions in circulation had become sufficiently saturated with copper to permit the operation of the electrolytic plant. On June 18, the first car of cathodes was shipped east to be melted and cast into the finished shapes.

The process adopted was as follows:

1. Mining by steam shovels; the maximum size to be controlled by the size of a fragment that will pass the shovel dipper.

2. Transportation of the ores in cars that will stand up to the rough service and discharge freely any fragments that passed through the dipper of the steam shovel.

3. The delivery of the ore, without any storage other than cars, directly into a crusher that will receive any fragment discharged by the car.

4. Crushing of steam-shovel size to as near ¼ in. as practicable.

5. Leaching the crushed ore 8 days by a counter-current system and upward circulation, using sulfuric acid and such ferric sulfate as is inherent in the process.

6. Reduction by sulfur-dioxide gas of the ferric iron remaining in the neutral solutions from the leaching tanks.

7. The electrolytic deposition of part of the copper from this reduced solution, which is then returned to the leaching solution.

8. The continuous discharge of such portion of the neutral solution as is necessary to prevent accumulation of sulfates, other than copper, to the saturation point.

9. The recovery of the copper content of such discarded solution as cement copper precipitated on iron.

10. The treatment of a part of this cement copper with solution from the electrolytic tank house to the end that the copper be returned to the circulation and a part of ferric sulfate be reduced.

TABLE 1.—*Summary of Results. May* 1, 1917 *to May* 1, 1918

Total tons of dry ore charged to leaching plant	1,345,000
Total number of tanks charged	269
Total copper contents, per cent	1.631
Soluble copper contents, per cent	1.577
Insoluble copper, probably present as sulfide, per cent	0.054

Average proportion of ore on 4-mesh screen, per cent	41.9
Average proportion of ore through 20-mesh screen, per cent	19.1

Total number of tanks excavated	259
Average moisture in tailings, per cent	11.1
Total copper in tailings, per cent	0.338
Copper in laboratory washed tailings, per cent	0.254
Water-soluble copper in tailings, per cent	0.084
Average pounds of water-soluble copper per ton of tailings	1.6

Average number of days leached	9.7
Average gallons per minute advance through ore	1069
Circulation in tank, gallons per minute	4500
Average specific gravity of neutral advance	1.344
Average free sulfuric acid going on oldest ore, per cent	2.85
Average sulfuric acid in solution coming off newest ore, per cent	0.5

Average gallons advance per minute through towers	1005
Total iron in neutral advance to towers, per cent	2.36
Ferric iron in neutral advance to towers, per cent	1.06
Ferric iron in neutral advance from towers, per cent	0.46
Number of roasters in service	3
Average tons of ore roasted per day	68.5
Average sulfur contents of ore, per cent	42.7
Average sulfur contents of calcines, per cent	7.1
Average sulfur dioxide in gas towers, per cent	8.1
Average sulfur dioxide in gas from towers, per cent	1.9
Average pounds of sulfur consumed per pound of ferric iron reduced	0.57

Average gallons per minute through tank house	1005
Average copper content of solution entering tank house, per cent.	3.01
Average copper content of solution leaving tank house, per cent	2.53
Average copper content removed from solution through tank house, per cent	0.48
Average ferric iron contents of solution entering tank house, per cent	0.45
Average ferric iron contents of solution leaving tank house, per cent	0.99
Per cent. of theoretical oxidation	65.6
Average current density, amperes per square foot	6.6
Average voltage between anode and cathode	2.00
Average weight of cathode shipped, pounds	127
Number of tanks on cathodes	120
Number of tanks on starting sheets	23
Number of starting sheets made	266,453
Per cent. of starting sheets scrapped	11.4
Pounds of electrolytic copper produced	24,400,532

Total kw. hr., A. C. charged to electrolysis	34,865,096
Pounds of copper per kw. hr., A. C	0.70
Pounds of copper per kw. hr., D. C	0.82

Total tons of acid (60° B. sulfuric acid) charged to plant	59,809
Pounds of 60° B. acid per ton of ore leached	90.3
Pounds of 60° B. acid per pound of copper dissolved	3.56
Pounds of 100 per cent. acid per pound of copper dissolved	2.76

Average pounds of copper dissolved per ton of ore leached	26.06
Average per cent. of total copper dissolved	79.89
Per cent. of total copper into process shipped as electrolytic copper	53.70
Per cent. of total copper into process shipped as cement copper	15.13
Per cent. of total copper tied up in process	10.00
Per cent. of total copper produced as electrolytic	75.33
Per cent. of total copper produced as cement	24.67

			Per Cent.
Total pounds of copper to process		43,847,000	100.00
Total pounds of copper produced		32,392,565	73.88
As electrolytic	24,400,532 lb.		
As cement	7,992,033 lb.		
Total pounds of copper in solution May 1, 1918		1,902,768	4.34
Total copper unrecovered,			
In tailings as insoluble copper		6,381,242	14.55
In tailings as water soluble copper		2,110,332	4.81
Unaccounted for		1,060,907	2.42

Crushing

The ore is mined by steam shovels and is loaded and delivered to the crushing plant in side dump cars. The crushing plant is divided into two departments, coarse and fine, which are separated by a 10,000-ton storage bin. The coarse-crushing department consists of a No. 24 gyratory crusher set on a high concrete pedestal. Four No. 8 crushers of the same type, two on each side, receive the product from the large crusher and reduce it to about 4-in. (101 mm.) cubes. This product is taken by two 36-in. (91 cm.) conveyors to the storage bins. The conveyors have magnetic head pulleys; there are also powerful 53-in. (134 cm.) magnets hung over each belt.

The superstructure provides a runway and a 40-ton crane is installed over a No. 24 gyratory crusher for handling parts in repair and for breaking jams in the bowl of the crusher. The 10,000-ton storage bin between the coarse and fine crushers is of steel built on an elevated reinforced-concrete platform. It is flat-bottomed and the ore is drawn

from it automatically onto a set of four 20-in. belt conveyors, equipped with magnetic head pulleys, which deliver the ore to four units of Symons 48-in. vertical-shaft disk crushers. Each unit consists of three crushers, which are interchangeable in every respect. The first is set to crush to inch cubes. The material so crushed is elevated and screened; the undersize by-passes the remaining two crushers, which are set in parallel. The oversize passes to these two crushers which are set to crush to the desired size. The entire product is fed to a system of belt conveyors, which lead through a sampling plant to the leaching vats, which furnish the only storage for the crushed ore. The disk crushers are run by direct connected 75-hp. alternating-current motors at 400 r.p.m. The pinion shaft is long, permitting the motors to be set in a separate room, thus being protected from dust.

In determining the proper size to which ore should be crushed for leaching, two main ideas are kept in view, crushing for extraction and crushing for percolation. The coarser the product, and the smaller the amount of fines, the freer the circulation will be; but the extraction will tend to vary with the size of the particles. The finer the ore is crushed the higher the extraction will be until such fine crushing materially interferes with the circulation of the solutions. The more uniform the product the better the circulation will be, and, other things being equal, the higher the extraction. The ore used in early leaching tests was crushed by rolls that produced a large amount of fine material. Later a Symons vertical 48-in. disk crusher was used; Symons disk crushers were installed in the 5000-ton plant.

Table 2 gives screen analyses of the ore crushed at Ajo during the first year and represents the analyses on about 1,345,000 T. of ore.

The fracture planes of the porphyry are such that the ore has a tendency to break into thin flat pieces, so that the leaching product is better than the screen tests indicate. All fracture planes in the Ajo ore contain more or less malachite and, as a result of crushing, the fine material contains more copper than the coarse. The screen analysis in Table 3, representing a sample from 150,000 T. of ore treated during the month of March, 1918, shows the distribution of the copper values.

The mine is operated in two 8-hr. shifts and the coarse-crushing plant is necessarily operated for the same length of time, there being no storage between the plant and the mine. The fine-crushing plant is run from 3 p. m. to 7 a. m., during which time the charge for a 5000-ton tank is crushed; but as there is a storage bin between the two crushing plants the fine plant can be operated for the full 24 hr. if necessary. Serious trouble has been experienced from the fine dust in the crushing plant. This nuisance has been somewhat abated by wetting down the ore on the cars as it comes from the mine, and a dust-collecting system is now being installed in the fine-crushing plant.

TABLE 2.—*Summary of Screen Sizing Tests for First Year of Operation*

Month	3 Mesh, Per Cent.	4 Mesh, Per Cent.	6 Mesh, Per Cent.	8 Mesh, Per Cent.	10 Mesh, Per Cent.	14 Mesh, Per Cent.	+20 Mesh, Per Cent.	-20 Mesh, Per Cent.
May	25.8	18.8	14.2	9.7	7.2	4.1	3.6	16.6
June	15.5	18.6	15.7	11.7	8.1	5.5	4.2	20.7
July	20.6	18.8	14.9	9.7	7.5	5.2	4.1	19.2
August	24.7	16.0	12.2	8.6	7.0	5.3	4.4	21.8
September	26.9	17.5	13.2	9.1	6.9	4.9	3.8	17.7
October	23.3	17.8	13.9	9.5	7.2	4.5	4.2	19.6
November	28.9	16.9	12.4	8.5	7.1	4.9	3.8	17.5
December	41.4	13.2	9.7	7.2	5.2	4.1	3.3	15.9
January	37.6	12.6	10.8	7.3	6.1	4.5	3.8	17.2
February	30.0	14.7	11.9	8.5	6.8	4.8	3.7	19.4
March	24.3	15.4	13.9	9.0	7.6	5.6	4.9	19.3
April	19.8	17.1	13.5	9.9	7.6	5.6	4.8	21.7
Average	26.3	16.6	12.8	9.1	7.0	5.0	4.2	19.0
Extremes—								
Charge No. 144 (1917)	56.6	9.6	6.6	5.0	4.0	3.1	2.3	12.8
Charge No. 15 (1917)	7.6	15.2	19.5	14.3	10.1	5.2	5.2	22.9
Charge No. 85 (1917)	16.1	11.3	12.2	9.9	9.0	7.1	6.0	28.4
40-ton Test Plant:								
Average 290 charges	9.7	21.0	20.0	14.1	8.0	6.0	4.2	17.0

TABLE 3.—*Screen Analysis of Ore Treated During March,* 1918

Mesh	Per Cent.	Copper, Per Cent.	Mesh	Per Cent.	Copper, Per Cent.
On 3	24.3	1.41	On 10	7.6	1.50
On 4	15.4	1.35	On 14	5.6	1.61
On 6	13.9	1.38	On 20	4.9	1.71
On 8	9.0	1.46	Through 20	19.3	2.03

Calculated—1.548 per cent. copper
Actual analyses—1.530 per cent. copper

The ore, as finally crushed, is conveyed by a system of 28-in. (71 cm.) belt conveyors through an automatic sampling plant and thence continuously to the leaching plant. There are twelve leaching tanks arranged in two parallel rows of six each. The aisle between the two rows of tanks is 108 ft. (32.9 m.) wide and contains what is known as the

central structure. This so-called central structure consists of six heavy reinforced-concrete piers supporting steel trusses that span from pier to pier. This central structure has two decks, the upper carrying the belt conveyor, the lower, the solution launders and pipe lines. Each unit pier consists of four smaller piers, each supporting a pump and its pipe connections. Underneath this central structure and parallel to it are two drainage launders used to carry the solutions from the leaching tanks to the solution storage.

Leaching

The leaching tanks, 88 ft. (26.8 m.) square and 17 ft. 4 in. (5.28 m.) deep inside, are built of reinforced concrete with wooden bottoms. These have a capacity of 5000 T. each of crushed ore. The walls are 9½

Fig. 1.—Leaching tanks and excavator, New Cornelia Copper Co.

in. (24.1 cm.) thick and are strengthened outside by concrete buttresses. The bottom is of 3 by 8-in. (7.6 by 20.3 cm.) Oregon pine laid edgewise, and is supported by concrete foundations. The sides and launders of the tanks are lined with 8-lb. (3.6 kg.) lead and the bottom with 6-lb. 4-per cent. antimonial lead. The filter bottom is laid over the lead bottom and consists of 5 by 12-in. (12.7 by 30.4 cm.) joists on edge laid on 16-in. (40.6 cm.) centers, covered with 2-in. ship-lap planks that are bored with ⅜-in. (9.5 mm.) holes on 2-in. (50.8 mm.) centers countersunk from below. Under the center of the filter bottom, and at right angles

to the wooden floor joists, there is a distributing launder 5 ft. (1.5 m.) wide by 2 ft. 9 in. (0.8 m.) deep, set in the floor through which the solution enters and from which it is distributed under the filter bottom. The lead lining on the sides of the tanks is protected from abrasion by a covering of 2-in. planks held in place by 6 by 8-in. (15.2 by 20.3 cm.) vertical posts clamped at the bottom and top. At the top and sides of each leaching tank are two overflow launders extending the length of the tank, one end being connected with the suction of a circulating pump. The charging is done by means of a machine especially designed for this plant and known as the spreader bridge; it consists of a traveling bridge of structural steel which spans the tanks and travels, as desired,

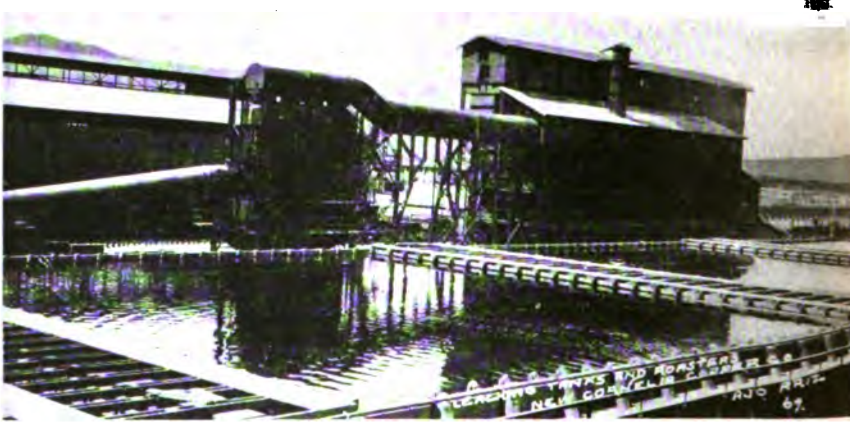


Fig. 2.—Leaching tanks and roasters, New Cornelia Copper Co.

lengthwise with the row. The bridge supports a 28-in. (71.1 cm.) belt conveyor, which receives the crushed ore from the belt on the central structure. A tripper on this belt spreads the ore in the leaching tanks.

At the present time the tanks are charged by filling to the top of the tank at one side, allowing the ore to assume its natural slope, or about 45°, and then continuing at one side and discharging the ore at the top of the slope, allowing the coarser material to run to the bottom and the finer to remain somewhat higher up, thus giving a rough classification The bridge is moved slowly forward as the filling of the tank progresses. This plan was suggested by the engineers of the Chile Copper Co., who have obtained the best results through this method of filling.

The crushed ore is leached from six to eight days by a counter-current

system and upward percolation, using dilute sulfuric acid as the principal solvent of the oxidized copper minerals.

The solution in each tank is circulated by two 15-in. (38.1 cm.) vertical-centrifugal pumps of 3500 gal. (13,248 l.) per min. capacity each. These are driven by direct-connected 40-hp. vertical motors. The head against which the pumps work is 28 ft. (8.5 m.), which is virtually equivalent to the friction head of the solution passing through the ore. The discharge from one of these pumps is provided with a by-pass which permits a portion of the solution to be advanced to the next tank. Both pumps are throttled to give a circulation of about 4000 to 5000 gal. per min. through the ore. Of this amount about 1000 gal. (3785 l.), called the solution advance, is continuously passing through from tank to tank. The high-acid solution (3 per cent. free sulfuric acid) coming from either or both the tank house and the solution storage and going on the oldest ore, is called the "acid advance." The nearly neutral solution coming off the newest charge and going to the reduction towers is known as the "neutral advance."

Cycle of Leaching Operation

To understand more clearly the various operations taking place during a leach cycle, the accompanying flow sheet for a day's operation should be followed. The arrangement of the piping and launders permits the advance of solution in but one direction, clockwise. The tanks are also charged in this order. Of the twelve tanks, eleven are used as leaching tanks and one as a solution settler. Of the eleven tanks, seven always contain ore in the process of leaching. Referring to flow sheet (20–20), if we assume the ore in tank 10 to be the oldest and that in tank 5 to be the newest in circuit, then tank 6 is being charged with ore, tank 7 is empty, tank 8 is being excavated, and tank 9 is in the various stages of washing and draining.

When the charging of tank 6 has been completed and the tank is ready for the leaching cycle, the acid advance is increased to the maximum (2000 gal. per min. for 4 hr.) by the addition of solution from the storage tanks A or E. Meanwhile the usual advance of about 1000 gal. per min. continues to go from tank 5 to the reduction towers and the excess solution is advanced to tank 6 until the ore is covered; this is to prevent any interruption in the solution flow to the towers. When the ore is covered this additional advance is cut off and the normal advance resumed. The solution on the new charge is now circulated on itself for about 4 hr., or until clarified. Tank 6 is now put into circuit and the neutral advance to the towers comes off tank 6 in place of tank 5.

The leaching of the ore in tank 6, now begun, continues for 7 days,

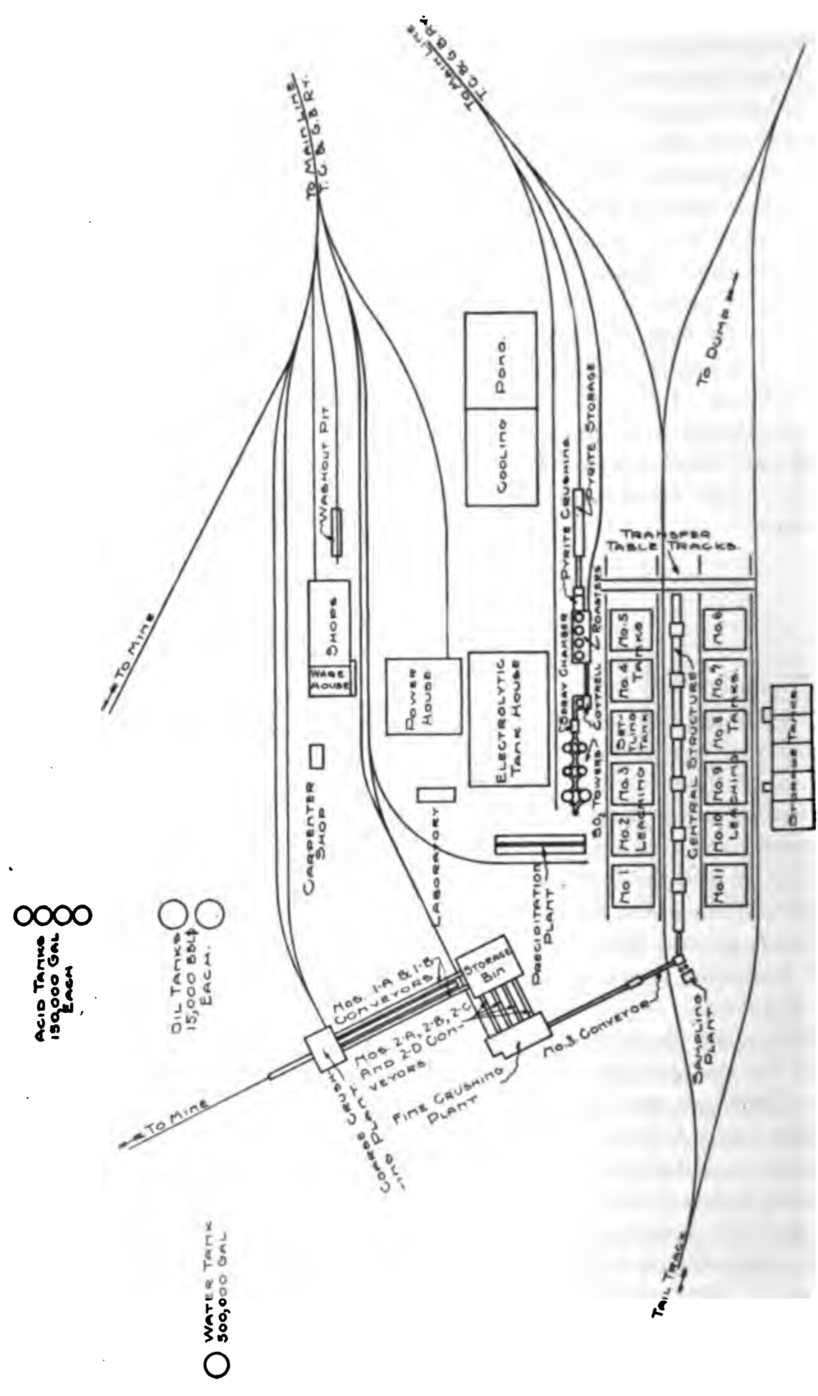


FIG. 3.—GENERAL PLAN OF PLANT.

during which period the free acid in the solution has varied from 0.5 per cent. on the first day to 3.0 per cent. on the seventh. To show the acid concentrations during a leach cycle, the daily analyses of the solution going on each day were averaged for some 18 consecutive charges. The results were as follows:

	Per Cent.
Free H_2SO_4 going on the ore the seventh day	3.0
Free H_2SO_4 going on the ore the sixth day	2.6
Free H_2SO_4 going on the ore the fifth day	2.2
Free H_2SO_4 going on the ore the fourth day	1.9
Free H_2SO_4 going on the ore the third day	1.6
Free H_2SO_4 going on the ore the second day	1.2
Free H_2SO_4 going on the ore the first day	0.9

At the end of the seventh day, the acid advance from the tank house is transferred from tank 10 to tank 11. Upon the entrance of a new charge into the circuit the solution remaining in the oldest tank is drained to the solution storage, where it is standardized with acid and is later used as acid advance. After thorough draining, the tank is ready for the wash water.

As the copper entrained in a charge after leaching is about one-third of the total copper dissolved, the question of thorough washing is very important. Four successive wash waters with drainings are used. During the 3 hr. circulation that each wash is given, an equilibrium between the dissolved copper in the tailings and that of the wash water being applied is expected to be reached. To follow more readily the method of washing a charge, the flow sheet is referred to. When tank 9 has been thoroughly drained, the charge is covered with wash water from wash-water tank 1, circulated, and then drained to solution storage tank A or E; this constitutes the first wash. The charge is now covered with wash water from wash-water tank 2 and similarly circulated, and then drained into wash-water tank 1. In the same manner, the wash water from wash-water tank 3 is put on, circulated, and drained. The fourth or last wash, consisting entirely of fresh water, is pumped, circulated, and drained into wash-water tank 3.

In this manner the fourth wash of any one charge is used as the third wash of the succeeding charge, the third used as the second, and the second as the first. In other words, each wash water is used four times, the copper contents increasing each time, when it is incorporated into the system to make up the continuous losses of solution. These losses are due to evaporation, discard, and solution entrained in tailings.

The average analyses of the wash waters for March, 1918, were as shown in Table 4.

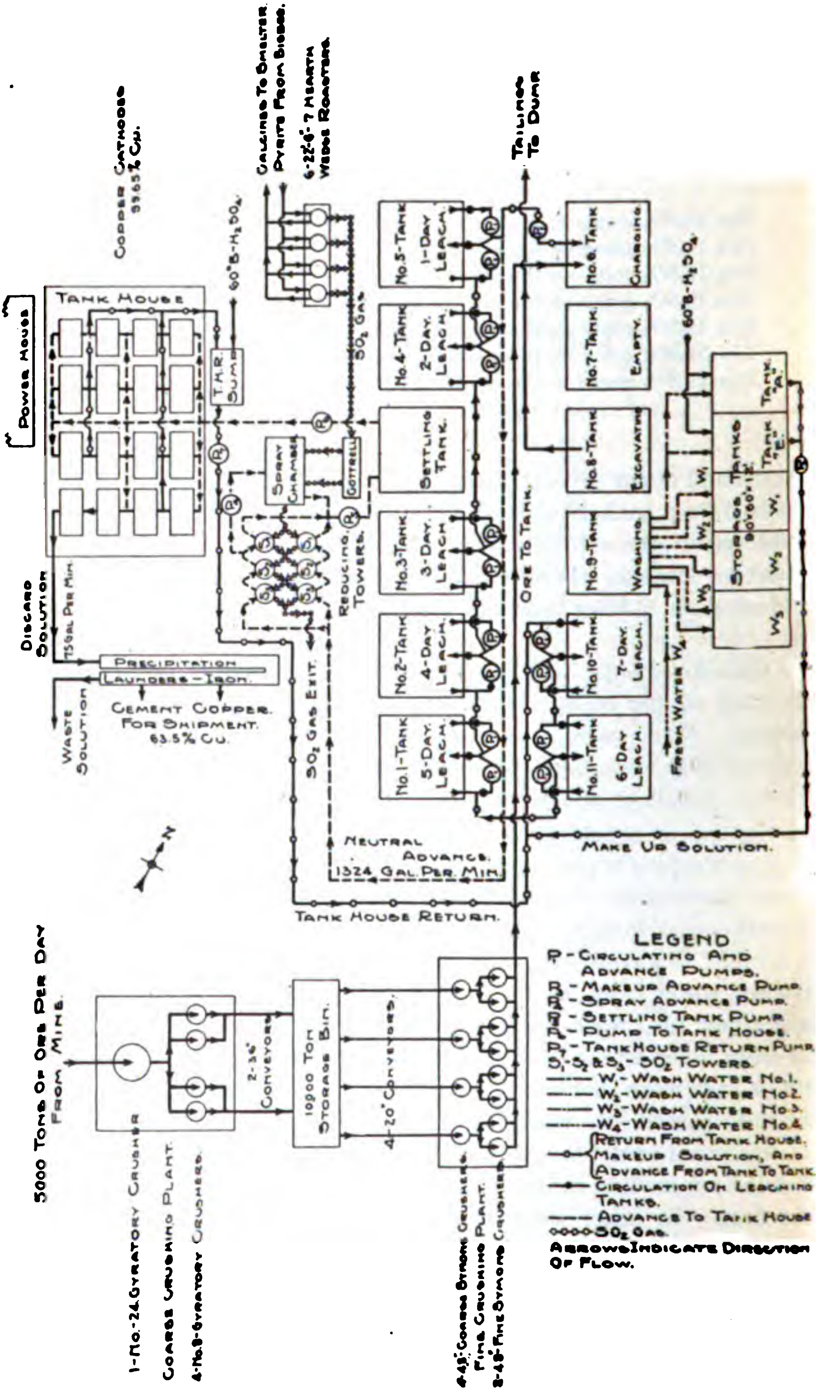


FIG. 4.—GENERAL FLOW SHEET OF ORE AND SOLUTION.

TABLE 4.—*Analyses of Wash Waters for March*, 1918

	Solution Off	First Wash	Second Wash	Third Wash	Fourth Wash
Free H_2SO_4, per cent	2.56	1.02	0.68	0.48	0.10
Copper, per cent	2.40	1.61	1.15	0.74	0.38
Ferrous iron, per cent	1.58	1.06	0.70	0.47	0.04
Ferric iron, per cent	0.72	0.48	0.31	0.17	0.26
Specific gravity	1.30	1.20	1.13	1.08	1.05

To obtain the best results in washing a charge, the tanks should be thoroughly drained after each wash and the circulation should be limited by the time required to reach an equilibrium. As each 0.1 per cent. of copper in the last wash water means a loss of over 1000 lb. of dissolved copper per day, it is evident that the washing has not yet been perfected. Limited solution storage and launder installation during the first year has made the use of a fifth wash water impracticable. Probably the best recommendation made in connection with the use of a fifth wash water was the precipitation of its copper contents on scrap iron simultaneously with its use, using the same water repeatedly until it reaches a point where it is no longer effective. Plans are now being considered for this installation. The losses that the wash waters replace are shown in Table 5. The total is about the volume of one wash water. The average moisture in the tailings for the first year of operation was 11.12 per cent.

TABLE 5.—*Losses of Solution*

	Gallons per Ton of Ore	Gallons per Day
Evaporation	5 to 10	25,000– 50,000
Discard	28 to 30	140,000–150,000
Entrained in tailings	24 to 26	120,000–130,000
Total	57 to 66	285,000–330,000

Removal of Tailings

After a charge has been washed and drained, the tailings are removed from the tank by means of a Hulett unloader. The machine was furnished by the Wellman-Seaver-Morgan Co., and is similar to unloaders used on the Great Lakes for unloading iron ore from boats. A heavy steel bridge on trucks spans the leaching tanks and travels their entire length.

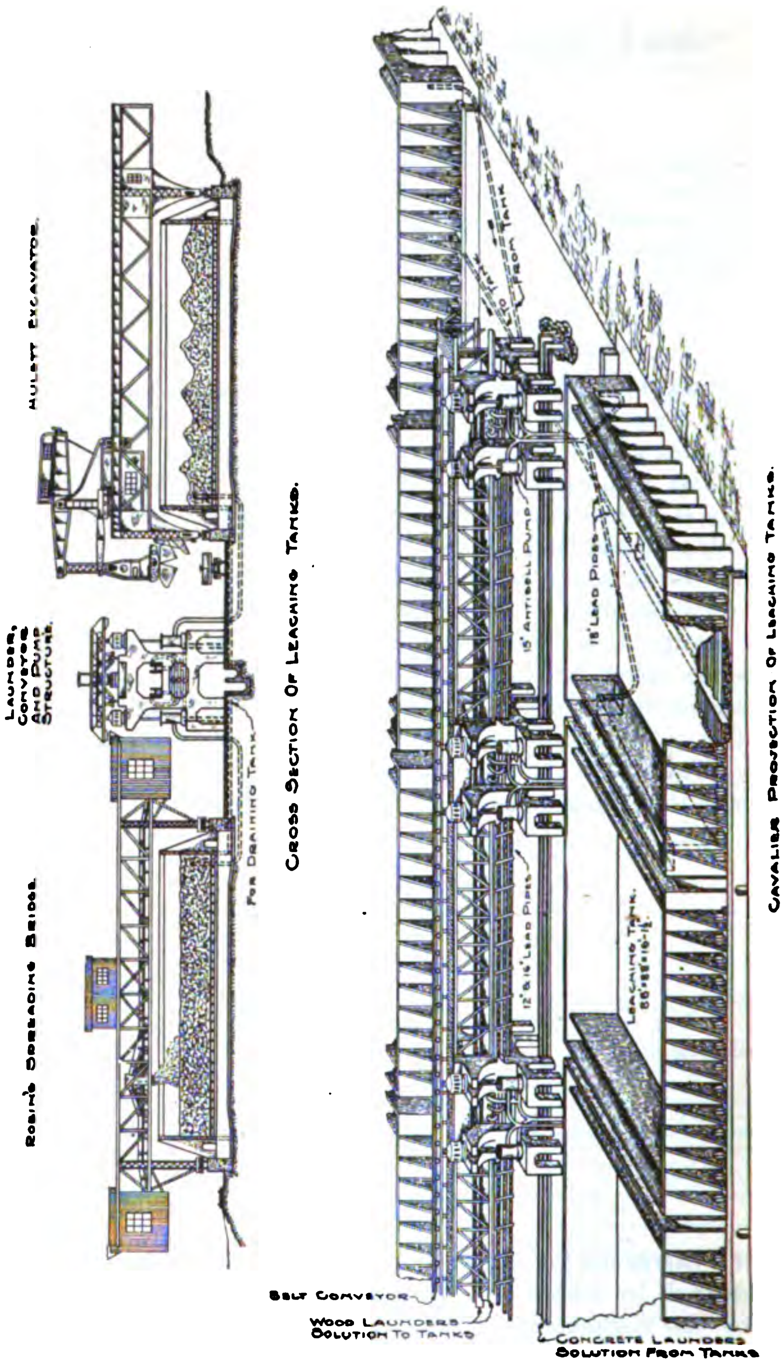


FIG. 5.—CROSS-SECTION AND CAVALIER PROJECTION OF LEACHING TANK.

On this bridge travels a trolley carrying a walking beam, bucket leg, and bucket of 12 T. capacity. The unloader has a rated capacity of 500 T. per hr. and will generally excavate a tank of tailings in 10 to 11 hr. An engineer and an oiler are required to operate it. A description of this machine has been written by Franklin Moeller, Engineer for the Wellman-Seaver-Morgan Co.[3] Two eight-car trains are released from the mine service at 4.30 p. m. for the transportation of tailings. Twenty-one to twenty-three train loads of eight cars each are required to excavate a tank. The tailings are taken to a dumping ground located about a mile from the plant. The dump is on gently sloping ground with a uniform grade of 1 per cent., the end of the present dump being about 80 ft. (24.3 m.) above the original ground.

Solution

The acid advance during the first year has varied from 869 to 1324 gal. (3289 to 5011 l.) per min. While we found that the more rapid advance appeared to give better extractions, we also found that the acid consumption was greatly increased. It is of interest to note that the per cent. of free acid coming off the newest charge averaged practically the same for an advance of 869 gal. per min. as for an advance of 1324 gal. per min. To show the normal decrease in acid and increase in copper and other constituents in the solution advance in one passage through the leaching tanks, the average analyses for the month of March, 1918, are given in Table 6.

TABLE 6.—*Analyses of Solution for March,* 1918

	Acid Advance	Neutral Advance
Free sulfuric acid, per cent	3.00	0.48
Copper, per cent	2.38	3.04
Iron as ferrous iron, per cent	1.57	1.61
Iron as ferric iron, per cent	0.69	0.72
Alumina, per cent	2.53	2.60
Specific gravity	1.290	1.305

There were originally some 13,000,000 T. of thoroughly oxidized ore, consisting principally of malachite together with small amounts of cuprite and chrysocolla distributed through a monzonite-porphyry gangue. Of this tonnage over 10 per cent has already been treated. It came in

[3] *Bulletin* No. 140 (August, 1918) 1229.

nearly equal quantities from three widely separated parts of the orebody. From this it is reasonable to believe that equally good or better results may be expected from the remainder. The ore so far mined has been better than the sampling of the property indicated, averaging 1.631 per cent. total copper as against 1.54 per cent. reported. Occasionally small quantities of sulfides are encountered, but not enough to make it worth while to treat this ore separately. Both the total and the soluble copper content of each charge of ore bedded is determined. The difference between the total copper and the soluble copper is an indication of the quantity of copper present as sulfides; for the first year of operation it was 0.054 per cent.

Comparing the analyses and assays on corresponding composite samples of the ore before and after leaching, it is found that a measurable quantity of iron, alumina, and magnesia has been dissolved. Table 7

TABLE 7.—*Analyses of Ore Before and After Leaching, February,* 1918

	Heads, Per Cent.	Tails, Per Cent.		Heads, Per Cent.	Tails, Per Cent.
SiO_2	67.04	69.28	P_2O_5	0.13	0.110
Fe, total	5.05	4.33	Na_2O	1.73	1.60
Al_2O_3	12.30	11.50	K_2O	3.34	3.31
CaO	0.63	0.60	TiO_2	0.44	0.48
MgO	1.52	1.24	CaO as $CaSO_4$		0.27
Mn	0.025	0.02	Fe as ferrous iron	3.57	2.05
S	0.05	0.26	Fe as ferric iron	1.48	2.28
S (sol. in H_2O)		0.16	H_2O	0.95	0.93
Cu, total	1.57	0.28	Au, ounces per ton	0.014	0.014
Cu, (sol. in H_2SO_4)	1.51		Ag, ounces per ton	0.161	0.157
Cu, in laboratory washed tailings		0.22			

gives the analyses of the ore before and after treatment during February, 1918. A study of the table will show relative solubilities of the various constituents of the ore in our present leaching solution. This was one of the first things to be determined in developing this process. Mr. Croasdale showed that the quantity of soluble material other than copper is comparatively small. Furthermore, comparison of the sizing tests of the ore before and after treatment shows that no appreciable physical change has taken place as a result of the solution of these constituents.

A part of the regular daily laboratory work consists of making analyses of a composite of hourly samples of the solutions on and off all leaching tanks. An average of the analyses of 18 consecutive charges is shown in

Table 8. The results proved so interesting that 94 charges were similarly averaged, including some charges that for various reasons were permitted to remain in the leaching tanks for 10 days. The results for the

TABLE 8.—*Composite Analyses of Solutions on and off Tanks*

	Gain in Copper Concentration, Per Cent.	Drop in Acid Concentration, Per Cent.	Converted Pounds per Ton of Ore Treated	
			Pounds of Copper Dissolved	Pounds of 60° B. H_2SO_4 Consumed
1st day	0.094	0.194	3.66	9.74
2d day	0.138	0.288	5.37	14.45
3d day	0.111	0.318	4.32	15.90
4th day	0.108	0.388	4.58	19.40
5th day	0.098	0.278	3.81	13.85
6th day	0.063	0.350	2.45	17.55
7th day	0.015	0.394	0.58	19.60
8th day*	0.032	0.394	1.24	19.60
Total	0.659	2.604	26.01	130.09

* The eighth day represents the maximum acid solution.

first eight days on these 94 charges checked very closely those of the 18 eight-day charges; therefore, a comparison will be made only of the last four days of the leaching period. From this, it is obvious that the 0.7 lb. of copper gained per ton of ore leached on the last two days was obtained at a cost of nearly 43 lb. (19.5 kg.) of 60° B. sulfuric acid,

TABLE 9.—*Copper Dissolved and Acid Consumed*

Number of Charges Averaged	Pounds of Copper Dissolved per Ton of Ore Treated		Pounds of 60° B. Acid Consumed per Ton of Ore Treated	
	94	18	94	18
7-day leach	25.7	24.8	109.2	112.7
8-day leach	26.9	26.0	129.6	130.0
9-day leach	27.3		150.9	
10-day leach	27.6		172.2	

and that there is a well-defined point where a high extraction is not profitable, if it is obtained by prolonging the time of contact between ore and acid. The pounds of material dissolved per ton of ore leached and the pounds of acid consumed appeared to be as shown in Table 10.

TABLE 10.—*Material Dissolved and Acid Consumed*

	Number of Days Leached									
	1	2	3	4	5	6	7	8	9	10
Cu, lb. per ton ore leached	3.60	8.75	14.50	19.11	22.47	25.00	26.72	27.93	28.26	28.65
Fe, lb. per ton ore leached	0.00	0.00	0.00	0.98	2.28	4.62	5.70	6.80	8.42	9.22
Al_2O_3, lb. per ton ore leached	0.00	0.17	1.69	1.40	2.29	2.76	4.61	7.33	10.22	13.65
MgO, lb. per ton ore leached	0.00	0.08	0.58	0.63	1.03	1.24	2.08	3.31	4.60	6.15
Pounds of 100 per cent. acid used per ton of ore	8.1	19.1	32.4	47.2	59.4	71.7	84.8	100.6	117.2	133.8

Leaching tests made on individual screen sizes in a small lead Pachuca tank holding approximately 200 lb. (90 kg.) of ore showed the rates at which the various impurities dissolve compared to that of copper. The ore was carefully screened, dried and weighed. The acid was weighed and the solution measured. The acid concentration was kept as near as was possible to that of the 5000-ton plant for the corresponding day. So far, tests have been completed on three screen sizes: Minus 0.525 in. plus 0.371 in., minus 3 mesh plus 4 mesh, and minus 6 mesh plus 8 mesh. The cumulative pounds of material dissolved per ton of ore leached are as follows:

TEST 1.—*Minus* 0.525 *Plus* 0.371-*mesh Screen*

	Hours Leached					
	24	48	72	96	120	144
Cu	10.34	14.36	16.97	18.82	21.22	22.14
Fe	0.43	0.79	1.21	1.64	2.03	2.57
Al_2O_3	1.04	1.71	2.19	2.64	3.26	3.36
MgO	0.23	0.31	0.35	0.40	0.70	0.80
CaO	1.19	1.36	1.18	1.22	1.19	0.98
P_2O_5	0.25	0.35	0.44	0.47	0.63	0.64

TEST 2.—*Minus 3-mesh Plus 4-mesh Screen*

	Hours Leached						
	13	30	48	72	97	125	144
Cu	14.80	18.30	21.10	22.30	24.10	25.60	26.60
Fe	0.65	0.89	1.29	1.74	2.16	2.96	3.96
Al_2O_3	1.18	1.99	2.47	2.46	2.79	3.71	4.08
MgO	0.25	0.32	0.34	0.39	0.49	0.73	0.90
CaO	1.52	1.15	1.08	1.01	0.92	1.05	1.08
P_2O_5	0.34	0.47	0.58	0.66	0.85	1.05	1.03

TEST 3.—*Minus 6-mesh Plus 8-mesh Screen*

	Hours Leached				
	12	24	36	60	72
Cu	18.20	21.10	22.50	22.60	23.40
Fe	0.70	1.00	1.15	1.55	1.85
Al_2O_3	1.69	2.28	2.59	2.88	3.01
MgO	0.26	0.34	0.37	0.31	0.42
CaO	1.27	1.18	1.08	1.08	1.08
P_2O_5	0.25	0.37	0.43	0.76	0.83

Calculating these results so as to show the solubility of impurities, in pounds per pound of copper dissolved, we have Table 11. These results indicate that fine crushing gives the highest extraction in the least time and with the minimum acid consumption.

TABLE 11.—*Impurities Dissolved per Pound of Copper*

	24-hr. Leach			72-hr. Leach			144-hr. Leach	
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3	Test 1	Test 2
Fe	0.042	0.043	0.044	0.071	0.078	0.079	0.116	0.162
Al_2C_3	0.109	0.080	0.108	0.129	0.110	0.129	0.152	0.166
MgO	0.021	0.016	0.016	0.021	0.017	0.018	0.036	0.037
CaO	0.115	0.102	0.060	0.069	0.045	0.046	0.044	0.044
P_2O_5	0.024	0.023	0.017	0.026	0.029	0.035	0.029	0.042
Total copper dissolved, per cent.	31.6	55.6	80.0	51.9	74.9	91.5	67.7	89.2
Pounds of acid consumed per lb. of copper dissolved	2.0	2.0	2.4	2.3	2.2	2.7	2.4	2.6

Acid Consumption

Upon the amount of acid consumed per pound of copper may depend largely the profit to be derived from the ore. During some 300 charges, the average acid consumption for the 40-ton plant was 2.8 lb. (1.3 kg.)

of 100 per cent. acid per pound of copper dissolved. This does not include that part regenerated in the tank house by the electrolytic deposition of copper or that obtained by the oxidation of the SO_2 to H_2SO_4 by the ferric iron. Mr. Croasdale's experiments showed a probable acid consumption of about 3.15 lb. (1.4 kg.) of 100 per cent. H_2SO_4 per pound of copper dissolved. This was of course the net consumption, as there was none produced or regenerated.

The amount of new acid introduced into the system during the first year has varied from month to month. By new acid we mean that part of the acid that must be brought in from an outside source, and represents only about 60 per cent. of that actually consumed in dissolving the copper in the ore; of the remaining 40 per cent., 32 per cent. is that generated in the towers by the oxidation of SO_2 and 8 per cent. is that regenerated in the tank house by the deposition of copper. In the final report on the experimental work, we stated that this acid consumption on the 5000-ton plant would not exceed 3 lb. of 100 per cent. H_2SO_4 per ton of ore leached.

For the first 5 mo. of the year, both the development work at the mine and the usual troubles in starting a plant prevented the delivery of 5000 T. of ore per day. This condition resulted in many of the charges being in process from 10 to 16 days, during which time great quantities of acid were consumed and but little copper extracted. For the last 7 mo. these conditions have been continually bettered and the average acid consumption for the first year of operation is 2.76 lb. (1.25 kg.) of 100 per cent. H_2SO_4 per pound of copper, or 3.36 lb. (1.5 kg.) of 60° B. acid per pound of copper, while the average for the last 4 mo. is 2.75 lb. (1.24 kg.) of 60° B. or 2.14 lb. (0.96 kg.) of 100 per cent. acid.

Approximately 60,000 T. of 60° B. sulfuric acid have been charged out to the leaching process during this first year of operation, or an average of 164.4 T. per day. During this period, some 1,345,000 T. of ore have been put into process, making an average acid consumption of 89.6 lb. (40.5 kg.) of 60° B. acid per ton of ore. The acid used is purchased from the Calumet & Arizona Mining Co. acid plant at Douglas, Ariz., and is delivered to Ajo, some 300 miles distant, in 50-ton iron tank cars at the rate of about three cars a day. Ample storage has been provided by the erection of four 1000-ton steel tanks, which permit of keeping 3500 to 4000 tons of acid in stock. A 6-in. (15 cm.) pipe line delivers the acid by gravity to the electrolytic tank house and to the solution storage.

Since the Ajo ores carry neither arsenic nor antimony, which are very deleterious impurities in cathode copper, the only other source of introduction for these impurities would be sulfuric acid. As the ore used for the production of the acid at Douglas carries but very small quantities of these impurities, the acid is of good quality, and there is no trouble from this source.

TABLE 12.—*Analysis of Sulfuric Acid (Oct. 1, 1917 to Jan. 1, 1918)*

	Per Cent.		Per Cent.		Per Cent.
H_2SO_4..........	80.86 (Equivalent to 61.5° B.)	Cu............	0.0618	Fe............	0.0219
		Pb............	0.0032	Zn............	0.0161
		Sb............	0.0063	Bi............	None
N_2O_3............	0.0064	As............	0.0058	Cl............	None
HNO_3..........	None				

An analysis of three months' composite sample of the acid is shown in Table 12. The acid occasionally has a pinkish tint, which upon examination was found to be due to a trace of selenium. After operating several months, a blood-red scum appeared in spots on the oil on the surface of the electrolyte. Anodes withdrawn at about that time showed a similar coating on the porcelain insulators. This scum or deposit was tested and found to be selenium.

To show how the acid is consumed, a typical solution analysis is given in Table 13. This is the analysis of a composite sample representing solution from the whole leaching and electrolytic cycle on Dec. 27, 1917. The specific gravity is 1.319. There are about 6,000,000

TABLE 13.—*A Typical Solution Analysis*

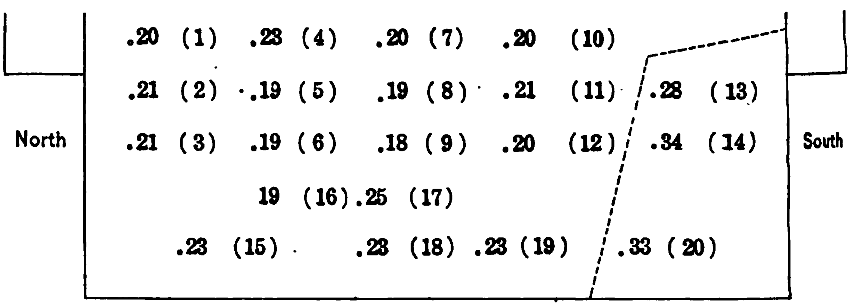
	Per Cent.		Per Cent.		Per Cent.
Cu..................	2.736	P_2O_5........	0.192	H_2SO_4, free..	1.500
Al_2O_3................	2.758	CaO........	0.055	As..........	0.003
Fe, total..............	2.456	MnO........	0.038	Sb..........	0.002
Fe as ferrous..........	1.511	Cl..........	0.012	Zn..........	0.033
Fe as ferric...........	0.945	SO_3.........	17.004	Se..........	Trace
MgO................	1.420				

gal. (22,710,000 l.) or approximately 30,000 to 35,000 T. of such solution on hand at all times throughout the plant, representing a tie-up on the average of some 900 T. of copper and 500 T. of acid (100 per cent.). Large as this may appear it is believed that it will not equal the quantity of copper that is tied up at the average smelter with an equal production.

The free acid in the solution going through the ore has been maintained at practically a constant percentage during the first year, but on comparing the per cent. of copper in the tailings of charges of like size and equal time of contact with the solution, wide variations are noted. No reason could be found for many of these variations.

To determine whether the copper contents of the tailings in the different parts of a tank are uniform, several tanks were sampled. The results on two of these tanks are shown. Each train-load was sampled separately. The tailings were sampled by taking eight 8-oz. (178 gm.) scoops full from the top of each car in predetermined places. The location in the cross-section of the tank from which the different samples were drawn was recorded. Since there was a difference in the per cent. of coarse and fine material in the different parts of the tank, the amount of copper was determined only in the tailings between 3 and 4 mesh. Figures in parenthesis are the cut number, while the others give the per cent. copper in the samples from these cuts.

Charge 61, *Tank* 6.—This tank was charged by filling one side to the top and then advancing from the south to the north side, as shown below.



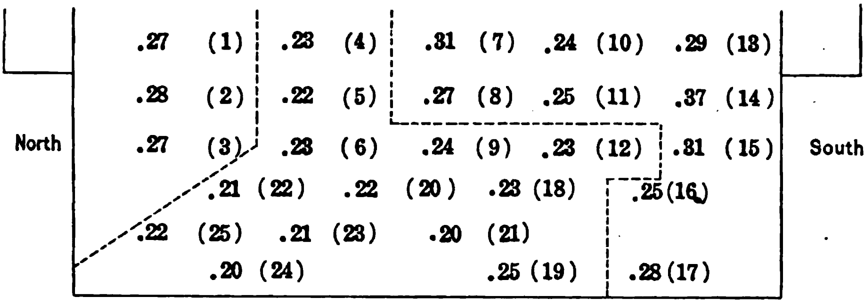
Tank charged, March 10, 2.10 p. m. Solution on, March 10, 6.30 p. m. Solution off, March 17, 4.00 a. m. Total time of leaching, 6 days, 9 hr., 30 min. Excavating began, 5 p. m. Finished, 4.00 a. m. Time, 11 hr. The last train-load was a general clean-up of the floor and showed 0.20 per cent. copper.

	Copper, Per Cent.
Average of above 21 train-loads, 4 mesh	0.223
Regular tailings sample, 4 mesh	0.24
Regular tailings sample, all mesh	0.24

Sizing Test, Mesh	3	4	6	8	10	14	+20	−20
Tailings								
On, per cent.	23.80	21.90	13.30	9.10	7.50	4.50	3.80	16.10
Cu, per cent.	0.44	0.24	0.15	0.14	0.14	0.15	0.14	0.22

Regular head sample, per cent. copper	1.51
Copper dissolved, per cent	84.1

Charge 127, *Tank* 6.—The tank was charged by filling both sides to the top and then advancing from the south to the north side, as shown in the following diagram.



Tank charged, May 14, 8.10 a.m. Solution on, May 14, 11 p. m. Solution off, May 21, 3.30 p. m. Total time of leaching, 6 days, 4 hr., 30 min. Excavating began, 5.20 p. m. Finished, 3.30 a. m. Time, 10 hr. 10 min.

	Copper, Per Cent.
Average of 25 train-loads, assay of 4-mesh material	0.25
Regular tailings sample	0.25
Sizing test on regular sample, 4 mesh	0.27
Total copper calculated from sizing test	0.25

Sizing Test, Mesh	3	4	6	8	10	14	+20	−20
Heads								
On, per cent.	19.60	17.30	15.00	10.40	7.60	5.50	4.20	20.40
Cu, per cent.	1.29	1.30	1.24	1.27	1.34	1.43	1.44	1.86
Tailings								
On, per cent.	14.70	20.40	14.60	10.00	8.40	5.40	4.40	22.10
Cu, per cent.	0.38	0.27	0.21	0.18	0.19	0.19	0.18	0.27

Regular head sample, per cent. copper	1.36
Calculated copper from sizing test, per cent. copper	1.42
Copper dissolved, per cent	81.60

The space within the dotted lines represents the zone of highest circulation and hence the most intense leaching action. The close agreement between the average of all the segregation assays and that of the regular tailings sizing test on similar sized material indicates consistent sampling. This is further emphasized by a comparison of the head sizing test (automatic sample) and the tailings sizing test, which is a hand sample.

Effect of Variation in Circulation

Charges were run with various rates of circulation, but no decided effect could be noted. Samples of ore taken from the top of a charge at regular intervals showed that where the solution had free access to the ore only 3 days were required to dissolve 80 per cent. of the copper in the ore, as against 6 days for the whole charge. These results and others lead to the belief that the crushing and the bedding of a charge so as to give the best circulation is of prime importance. In other words, the greatest care should be exercised in bedding and in regulating the circulation so as to prevent channeling of the solution. Upward circulation was selected because it reduces the tendency toward channeling and also effects more rapid solution of the copper.

Results obtained show that small variations in the density have no appreciable effect on the solubility of copper in the solution. In spite of the self-evident fact that a light solution is a more active lixiviant than a heavy one, a certain density must be maintained to keep the remainder of the process in balance.

At the beginning of operations the lead lining of the leaching tanks was exposed to the channeling of the ore and serious abrasion was noticed. The ore buoyed up by the heavy solution circulating at a high rate had completely worn through the lead in places. This condition was remedied by lining the tanks with 2 by 12-in. (5 by 30 cm.) planks and no further trouble has been experienced from this source. The solution was prevented from coming up between the plank and the lead lining by calking with oakum and asphalt. The bottoms of the leaching tanks are lined with 4-per cent. antimonial lead, while the sides are of chemical lead. Some trouble was at first experienced from splitting at the seams, between the hard and soft lead lining. This was caused by expansion, contraction, and defective burning. These seams were repaired and no further trouble was experienced. There were no important changes made either in the equipment or operation of the leaching division. The only change of interest was the reduction in the time of leaching from the original 8-day period to that of 6 to 7 days.

Water Supply

At the time the property was taken over, the nearest known water supply in sufficient quantity for our purpose was the Gila River, some 45 mi. (72.42 km.) to the north. The development of a closer water supply was one of the important problems to be solved. A large valley about 8 mi. (12.875 km.) northeast of Ajo was selected as a likely place and two wells were drilled. In both water was found at a depth of about 600 ft.

(182 m.) having a temperature of 104° F. At one of these places a two-compartment shaft was put down and a modern pumping plant installed. This shaft is now delivering 800,000 to 1,000,000 gal. (3,028,000 to 3,785,000 l.) of water per day, without any sign of decrease in volume. The pumping installation consists of a duplex double-acting high-pressure pump driven by a direct-connected synchronous motor. The water is pumped 6.7 mi. (10.7 km.) through a 10-in. (25 cm.) iron pipe line against a 1375-ft. (419 m.) head, including friction.

The sinking of another well, about a year later, by a rancher, some 6 mi. east of Ajo and about 12 mi. from the present well, proved the extent of the water course. The water found was of practically the same temperature and analysis. This made reasonably certain a continuous and plentiful supply. In this connection a comparison of the analyses of the water at these wells will be of interest. The analyses were made according to a well-known method of boiler-water analysis and are therefore comparable, see Table 14. Samples 1 and 2 were taken during development of the present supply. The analyses were made in the Calumet & Arizona laboratory, Bisbee, Ariz. Sample 3 was taken from plant tap near the end of the construction period, after pumping approximately 100,000,000 gal. from the well; sample 4 was taken after pumping approximately 400,000,000 gal., and sample 5 is water from the ranch well southeast of Ajo. The water from our main well is used for all purposes, including leaching plant, mine, railroad, and townsite. The great depth of the well and its distance from any possible sources of contamination make it an unusually good potable water. Further drifting in the present well would no doubt increase the flow should more water be required.

TABLE 14.—*Analyses of Water in Grains per U. S. Gallon*

	Sample 1 4-15-14	Sample 2 5-18-15	Sample 3 11-16-16	Sample 4 4-15-18	Sample 5 3-20-17
SiO_2, insoluble	3.90	2.71	2.28	2.52	2.22
$Fe_2O_3 + 1Al_2O_3$	0.17	0.11	1.14	0.05	0.37
$CaCO_3$	3.00	2.20	1.95	1.90	2.10
$CaSO_4$	none	none	none	none	none
$CaCl_2$	none	none	none	none	none
$MgCO_3$	0.73	0.71	0.84	0.80	1.13
$MgSO_4$	none	none	none	none	none
$MgCl_2$	none	none	none	none	none
Na_2CO_3	4.34	4.21	4.95	5.04	4.71
$NaSO_4$	8.52	7.78	7.70	7.66	8.99
NaCl	16.93	16.76	19.30	14.83	19.11

Reduction

In the electro-deposition of copper from a sulfuric-acid solution, iron if present will consume electric energy, by its alternate oxidation and reduction, thereby reducing the quantity of copper deposited per unit of current. During the experimental work the control of the ferric iron proved one of the hardest problems to solve. A patent diaphragm-anode was tried and gave good results, but was cumbersome and difficult to keep in order. Later, tests made on a process in which iron and alumina were precipitated as hydrated oxides by the addition of roasted copper ores gave good results. This method was considered too complicated for an ore of this character. The idea was then suggested of using the natural oxides and carbonates in the ore itself as the precipitant of the ferric sulfate; in other words, the precipitation of the principal impurities in the solutions upon the charge itself. Early tests made on a small scale were very promising, but tests carried out later on a larger scale failed to give the desired results. For the first 15 or 20 days, the copper in the newest charge of ore was sufficient to precipitate all the ferric iron that was contained in the solution passing through the ore. However, as the acid concentration on each charge increased, the precipitated ferric iron was redissolved and eventually accumulated to such an extent that the iron in the solution was in excess of the copper available as a precipitant.

Use of Sulfur Dioxide

It was now decided to resort to SO_2 reduction. The general opinion was that this was both unsatisfactory and difficult. This proved to be the case in solutions decidedly acid, but in the case where neutral or slightly acid solutions were used reduction proved quite easy. For these tests elemental sulfur was used, as it was believed that a gas with the maximum percentage of SO_2 was most essential and that a rich gas could only be produced by burning elemental sulfur. Owing to lack of knowledge of the operation of sulfur burners considerable trouble was experienced from volatilizing sulfur.

In the sulfite-pulp industry large quantities of sulfur gas are produced and absorbed, and accordingly the method of producing and absorbing the gas used in that industry was investigated. It was found that similar trouble from volatilized sulfur was experienced when making a gas containing above 12 per cent. of sulfur dioxide from elemental sulfur. It was also found that at some plants pyrites were used and that under proper conditions a gas of 12 per cent. SO_2 could be produced. The only objection in the sulfite-pulp industry to the use of pyrites was the tendency of small calcined particles to be carried into the solution and

thence into the pulp. Upon investigation it was decided to make use of the cheap and abundant supply of the high-sulfur low-copper ores of the Bisbee district.

The ore, some 75 T. per day, is unloaded from a trestle on a stock pile, underneath which there is a tunnel provided with a 24-in. (60.9 cm.) belt conveyor. The conveyor delivers the ore to a 13 by 20-in. (33 by 50.4 cm.) Blake jaw crusher, thence to a vertical-shaft 48-in. Symons disk crusher, giving a final product of about 3 mesh. A bucket elevator and a 20-in. conveyor equipped with automatic tripper delivers this crushed ore to eight hoppers situated above four Wedge roasters. These roasters are 22 ft. 6 in. in diameter, have seven hearths, and are belt-driven by 7½-hp. motors.

The gas leaving the roasters passes through a short balloon flue to a Cottrell precipitator, where the gas is cleaned of dust before it enters the spray or cooling chamber. The precipitator has forty-eight 13-in. collector tubes and a 65,000-volt circuit is used. At the beginning of operations, the gas cooled to such an extent before reaching the precipitator that sulfuric acid vapor present was condensed and prevented efficient precipitation. Insulating both the balloon flue and the precipitator with magnesia covering and cement remedied this condition. The gas, now practically clean, enters a large sheet-lead chamber locally called the cooling chamber. This chamber is 14 ft. (4.2 m.) square, 94 ft. (286 m.) long, and is built of 8 lb. (3.6 kg.) lead supported on a wooden framework. There are 38 nozzles distributed over the top and sides through which "neutral advance" is sprayed to cool the gas before it enters the towers. Between 90 and 100 gal. (340 and 378 l.) of solution per min. are required to supply these sprays. The ferric iron in the solution used in cooling the gas is practically all reduced and the solution joins that coming from the towers. The temperature of the gas in its passage through the spray chamber is reduced from 600 to 150° F. A flue, 20 ft. (6 m.) long and 6 ft. (1.8 m.) square, connects the spray chamber with the bottom of the first pair of towers, dividing the gas equally between them.

There are six towers arranged in pairs. Two pairs of the towers are part of the original equipment and are 40 ft. (12 m.) high and 20 ft. in diameter. These are built of sheet lead, supported on a steel framework. The top 10 ft. is made of 8-lb. lead, the second 10 ft. of 10-lb. lead, and the bottom 20 ft. of 12-lb. lead. The other pair, built during February, 1918, are 28 ft. (8.5 m.) in diameter, 40 ft. (12 m.) high, and are built of ordinary redwood tank construction, hooped together with iron rods. As an additional precaution against gas leakage, the wooden towers are painted with asphalt and covered with three-ply roofing paper under the hoops. The towers rest upon a reinforced concrete base, provided with a lead pan. All towers are filled with boards ⅜ in. (9.5 mm.) thick, 11 in. (32.9 cm.) wide, and placed on edge, the width of a board apart,

and in layers. Each layer is laid at right angles to the one immediately below it. The solution is distributed over the top of the towers by a system of launders provided with gas seals. Between the second and third pair of towers is a 60-in. (152 cm.) lead fan. This fan draws the gas from the roasters through the Cottrell precipitator, spray chamber, and third set of towers, and forces it through the second and first sets to the atmosphere. The temperature of the escaping gas is that of the atmosphere.

The solution (or neutral advance) to be reduced travels countercurrent to the flow of gas, that is, the most reduced solution comes in contact with the strongest gas. The solution coming from the newest tank of ore is pumped to the top of the third pair of towers by a 9-in. (21.8 cm.) 1600-gal. (6056 l.) per min. centrifugal pump. These are of the Antisell type and work against a 70-ft. head. The solution distributed by launders and gas seals flows down over the filling, thus coming into intimate contact with the rising gas. At the bottom of each pair of towers there is a concrete lead-lined sump, 6 ft. deep and 50 ft. long, into which the solution flows and is then pumped through the next pair of towers. From the first pair of towers the solution is pumped to the second pair, then to the third pair, and then to the so-called settling tank whence it goes to the tank house. The purpose of this settling tank is two-fold: one, to settle out the slime; the other, to get the benefit of the additional reduction that was found to take place in a neutral or slightly acid solution on standing. That the reduction of ferric iron in solution continues for some time after leaving the towers was first pointed out by G. D. Van Arsdale, who observed it during his work with SO_2 gas as a reducing agent.

TABLE 15.—*Reduction Data for First Year and for March,* 1918

	1917–1918	March, 1918
Average tons of sulfide ore roasted per day...	68.5	75.6
Average per cent. sulfur in ore............	42.7	42.6
Average per cent. sulfur in calcines..........	7.1	6.0
Average roasters in operation	3.6	4.0
Average per cent. ferric iron in solution entering towers	1.06	0.79
Average per cent. ferric iron in solution leaving towers	0.46	0.17
Average per cent. ferric iron in solution entering tank house	0.45	0.10
Average per cent. ferric iron reduced	0.61	0.69
Average per cent. of total iron reduced.......	57.8	87.3
Average circulation through towers, gal. per min.	1005	1324
Average specific gravity of solution through towers	1.344	1.305

Average per cent. total iron in solution through towers	2.36	2.40
Average per cent. sulfur dioxide by volume in gas entering towers	8.1	9.9
Average percent. sulfur dioxide by volume in gas leaving towers	1.9	0.8
Pounds of sulfur consumed per pound of ferric iron reduced	0.57	0.40
Average tons of new acid produced per day (estimated)	38.3	66.3
Average free acid in solution entering towers	0.37	0.48
Average free acid in solution leaving towers	1.54	1.70

A summary of the reduction data for the first year of operation and for March, 1918, is given in Table 15. The successful operation of the electrolytic plant depends, to a large extent, on the operation of the reduction plant. The reduction plant should be so designed that it will be capable of reducing more ferric iron than will be oxidized during the deposition in the tank house of the maximum quantity of copper. The less ferric iron there is in the electrolyte the higher will be the current efficiency. From the data obtained during the experimental work, only 50 per cent. of the theoretical tank-house oxidation took place. Based on these calculations, only four reduction towers were built. After the plant had been in operation a while it was found that the oxidation in the tank house was more nearly 70 per cent. of the theoretical and that four towers were insufficient to meet the conditions that would be imposed upon them by maximum tank-house capacity. Two more towers with a combined capacity of those already in use were then constructed.

To show the relative reduction in the various towers, an average was made of the solution analyses in and out of each tower for a period extending over one month; see Table 16. These results show the highest reduction taking place in the solution coming in contact with the gas

TABLE 16.—*Analyses of Solution In and Out of Reduction Towers*

	Ferrous Iron, Per Cent.	Ferric Iron, Per Cent.	Total Reduction, Per Cent.
Neutral advance entering towers	1.61	0.79	
Solution leaving first pair of towers	1.95	0.45	49.5
Solution leaving second pair of towers	2.14	0.26	27.5
Solution leaving third pair of towers	2.25	0.15	16.0
Solution leaving settling tank	2.30	0.10	7.0

containing the lowest per cent. of SO_2. This is partly due to the facts that the solution entering the first set of towers contains the lowest per cent. of free acid and the highest ferric iron content, and that these towers have the largest capacity. It is evident that the lower the density of the solution, the better will be the absorption and subsequent reduction. The lowering of the density is limited, however, by the operation of the remainder of the process; but it is believed that this fact should be considered as an important point in the operation of the towers.

It is of interest to note that during the first year 33 per cent. of the total acid required in dissolving the copper content of the ore is produced in the reduction towers according to the reaction:

$$Fe_2 (SO_4)_3 + SO_2 + 2 H_2O \rightarrow 2 FeSO_4 + 2 H_2SO_4$$

This, however, represents an increase of only 1.2 per cent. free sulfuric acid in the solution through the towers.

Electrolytic Deposition

The electrolytic tanks are housed in a structural steel building, 166 ft. (50 m.) wide and 280 ft. (85 m.) long, having sides only partly enclosed to give good ventilation. The operating floor is about 15 in. below the top of the electrolytic tanks. The floor in the aisles is of wood grating with the exception of the reinforced-concrete center aisle. The floors at the ends of the building are planks placed at the same level as those of the aisles. The electrolytic tanks are all on the same level, none in cascade.

The cellar, which is open on all sides, had an asphalt floor draining to gutters that lead to a sump at each end of the building. There is 8 ft. of headroom throughout the cellar to permit regular inspection of tanks, piping, and feed-wires.

The electrolytic tanks are arranged in banks with aisles between. There are 12 banks of 10 tanks each and 4 banks of 8 tanks each, making a total of 152 tanks. Each tank is separated from the adjacent tank by a 3-in. (76.2 mm.) air space. All tanks are made of Oregon pine, lined with 7 lb. (3 kg.) chemical lead. The inside dimensions of the tanks are 29 ft. 7 in. (9 m.) long, 4 ft. 9 in. (1.4 m.) wide, and 4 ft. 3 in. (1.3 m.) deep. These tanks are supported on concrete columns, and are insulated by tile blocks covered with sheet-lead caps. Each tank is provided with a 4-in. clean-out plug. There are also two perforated lead diaphragms, one at each end of the tanks, to assure a uniform circulation. The inlet to each tank is fitted with a 3½-in. diaphragm valve and a 3½-in. glazed stoneware goose-neck for insulating purposes. At the outlet end there is a lead overflow pan fitted with a 4-in. tile pipe suspended in a 10-in. lead boot connected to the discharge pipe.

Lead Anodes

Each tank has 84 anodes, making a total of 12,768 in the tank house. The anodes are of lead containing 3.5 per cent. antimony. The average weight of a lead anode is 215 lb. (97 kg.). They are 40 by 51 by ¼ in. (101.6 by 129.5 cm. by 6.3 mm.) thick, and are suspended by two ¼ by 1¼-in. copper bars secured to the tops of the anodes. The submerged surface of all anodes is 41 by 41 in. The spacing of anodes is 4½ ft. on centers. The distance from the bottom of an anode to the bottom of the tank is 8 in., while that of the cathode is 7 in. Short circuits are prevented to some extent by providing the anodes with eight conical glazed porcelain insulators distributed over the anode faces.

Much doubt was expressed about the life of the lead anode and some very positive statements were made regarding their probable length of life. Continuous service extending for over 1 year has failed to show appreciable oxidation. To obtain definite figures on the disintegration of lead anodes operating under such conditions as these, nine new anodes were carefully marked, weighed, and put into operation. These have been taken out at various times, weighed, and examined. During the first period of operation of 70 days, these anodes showed an increase in weight, due to oxidation, of about 0.94 lb. (0.42 kg.) per anode, or about 0.44 per cent. of the total weight. This amounted to 36 lb. (16 kg.) of lead per ton of copper deposited. During the second period of 42 days, there was an apparent loss in weight of lead; while during the third period, there was no change in weight within the limit of error in weighing. Basing calculations on these figures, it is evident that the oxidation of anodes will not be an important factor.

Previous to our 40-ton tests, little appeared to be known regarding the action of chlorine on lead anodes and much doubt was expressed as to the effect of small amounts of chlorine in a sulfate electrolyte. The water that was used in the 40-ton plant contained only about one-third of the amount of chlorine that is present in the water used in the 5000-ton plant. Something over 183,000 lb. of electrolytic copper analyzing 99.73 per cent. copper and 0.042 per cent. chlorine were produced in the 40-ton plant, and when checking back on the chlorine introduced into the system, it appeared that about 65 per cent. of it was deposited with the copper. Such also proved to be the case in the 5000-ton plant. The water used for all purposes at the plant averages 0.015 per cent. total chlorine. When starting up the plant and making up leach solution, the chlorine content of the solution gradually increased from 0.015 to 0.021 per cent. when the electrolytic tank house started operations, then decreased until it reached about 0.010 per cent. where it appears to be constant.

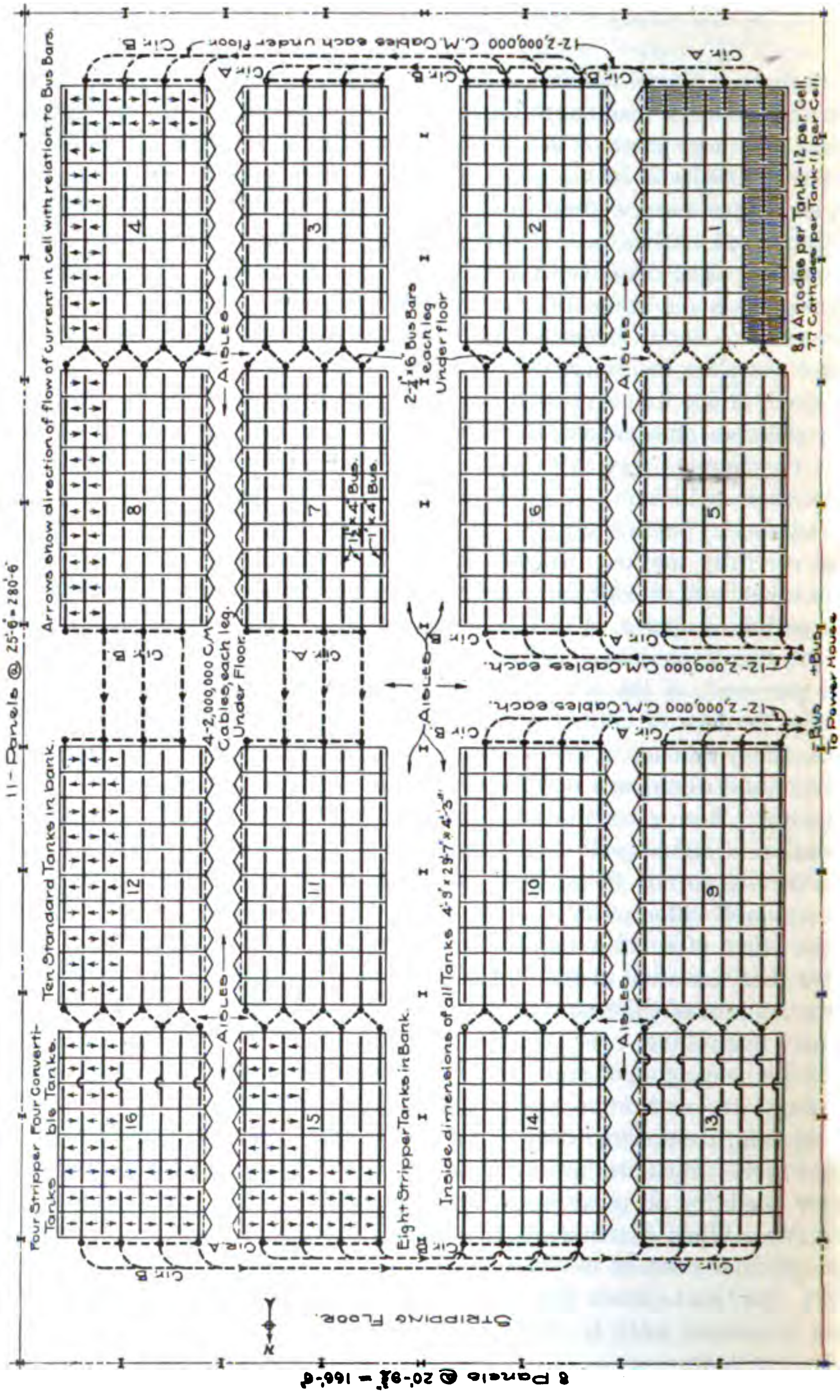


FIG. 6.—FLOW SHEET OF ELECTROLYTIC CONNECTIONS OF ELECTROLYTIC TANK HOUSE.

Cathodes and Starting Sheets

There are 77 cathodes to a tank, or 9779 cathodes in the tank house, exclusive of starting-sheet blanks. The cathodes are 42 in. (106 cm.) square and are totally submerged. They are suspended upon ½ by 1¼-in. (12.7 by 31.7 mm.) copper bars by loops made from starting sheets. The original starting sheets weighed about 15 to 18 lb. (6 to 8 kg.) while the finished cathodes weigh 130 to 140 lb. (58 to 63 kg.). At the present time 127 tanks are used for making cathodes and about 14 to 16 days are required to produce cathodes of the desired weight.

Crane service is provided by two 80-ft. (24 m.) span 5-ton Shaw cranes, operating the length of the building, each serving one-half of the electrolytic tanks. One section of 11 cathodes is removed at a time and carried to the center aisle, where they are washed with hot water to remove the salts and soluble copper. They are then landed on an iron frame to facilitate the hand trucking to the freight cars. Each car is sampled by drilling every twentieth cathode in the center and in diagonally opposite corners. All electrolytic copper, whether cathode or scrap, is shipped to the Raritan Copper Works at Perth Amboy, N. J., where it is melted, brought up to pitch, and cast into commercial shapes.

The cathodes produced have varied from 99.15 to 99.85 per cent. in copper content, the impurities being principally slimes, held by mechanical entanglement. The greater the density of the electrolyte, the lower is the copper content in the cathodes and the greater the insoluble matter, iron, and alumina. The cathodes always contain more or less chlorine, varying from 0.05 to 0.35 per cent. There being no arsenic or antimony in the ore, and very little in the acid, the average arsenic content of the anodes is less than 0.0015 and the antimony less than 0.0005 per cent.

There are 25 tanks operating on starting sheets, each tank containing 77 starting blanks, or a total of 1925 blanks. These are located in the eight-tank banks at the north end of the building. The starting blanks are of rolled 3.5 per cent. antimonial lead 53 by 43 by ¼-in. (134.6 by 109 cm. by 6.3 mm.) and are large enough to allow a small amount of trimming, which is done with a squaring shear. Grooved redwood sticks are used at the edge and bottom of the blank to cut the sheet to facilitate stripping, and are found to be satisfactory. The anodes in these tanks are 3.5 per cent. antimonial lead, and are 41 by 52 by ¼ inches. They do not have porcelain insulators, as these tend to spot the starting sheets. The spacing of anodes in these tanks is the same as in the commercial tanks. The tank construction and other details are likewise similar.

Eleven blanks are handled at one time by the crane, and placed on an iron stripping rack provided with a crawl so that the blanks can be carried, one at a time, to the center of the rack, where the starting sheets are removed by two strippers, one stripping from each side. After stripping,

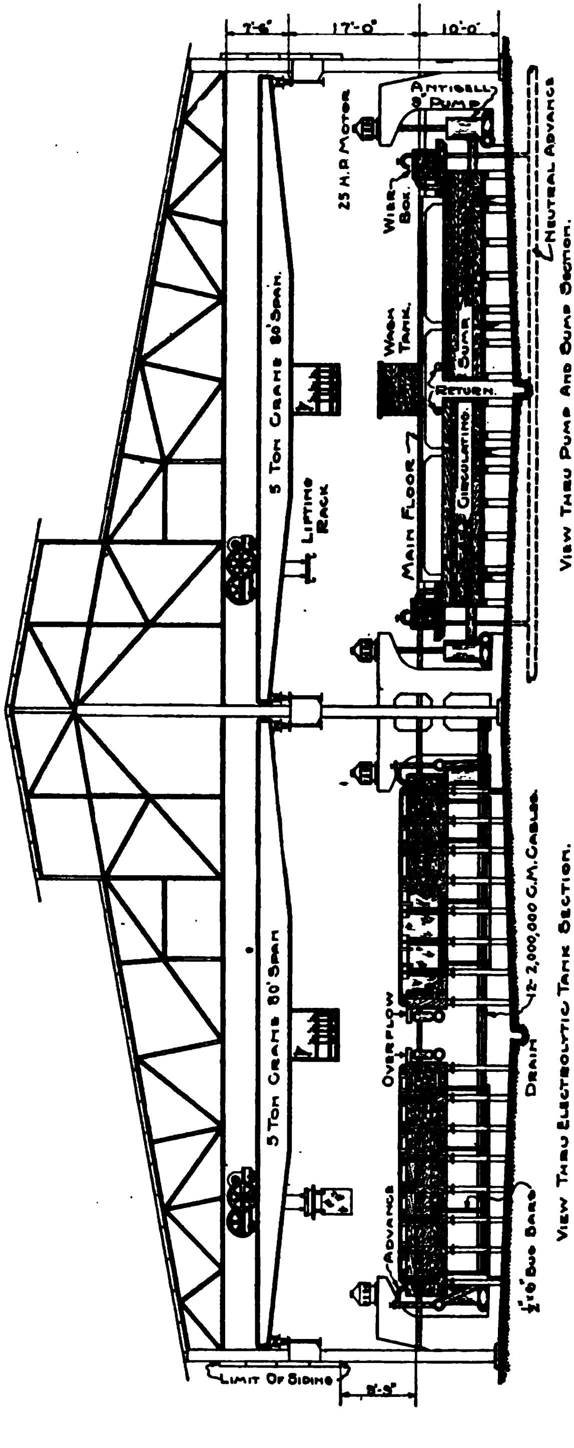


Fig. 7.—East and West Section through Tank House.

the blanks are oiled and placed on the opposite end of the rack to be returned by the crane to the tanks. Four men will strip, under favorable conditions, 924 sheets in 5 hr. The starting sheets, after being stripped and trimmed, are looped on a standard Morrow machine.

The electrodes hang parallel to the flow of solution (or parallel to the length of the tanks) to give a free circulation of the electrolyte. This method of hanging the electrodes was first brought to our attention by the work done at the Butte and Duluth works.

Electric Arrangement

Alternate busbars extending across the tanks connect the electrodes in parallel and the tanks in series (see illustration). These busbars, placed across the tank, divide it into seven sections or cells. The intermediate busbars are 1½ in. (38 mm.) wide and 4 in. (101.6 mm.) deep, while the end busbars are 1 in. wide and 4 in. deep. Soldered along the top of each busbar is a triangular piece of copper, ½ in. high, giving a point contact to the electrode bars. Small maple blocks impregnated with linseed oil insulate cathodes and anodes from opposite busbars. These busbars are supported on insulated iron castings, which in turn rest on the tank cleats. The current for the deposition of the copper is supplied to the tank house by two identical 15,000-amp. circuits, each circuit having 76 tanks in series. This arrangement gives the maximum current density of 8 amp. per sq. ft. of cathode surface when operating under normal conditions. With an average current efficiency of 80 per cent. this means a daily gain of about 10.25 lb. (4.6 kg.) per cathode, or a total capacity of 120,000 lb. of electrolytic copper per day. The drop of potential between anodes and cathodes has averaged very close to 2.00 volts. There is a tendency for the voltage to drop during the summer due to increase in temperature of the electrolyte.

Electrolyte

The solution flow in the tank house is part of a closed circuit with the leaching and reduction plant, receiving a continuous flow of solution from them. This flow, coming always off the newest ore, then through the towers and settler, is regulated by means of weirs and has varied from 800 to 1500 gal. (3028 to 5677 l.) per min., depending on operating conditions. This volume is divided among the 16 banks of tanks, those on starting sheets getting generally a little more than those on cathodes. By this arrangement each bank of tanks on cathodes receives between 60 and 70 gal. per min. of reduced solution. Each bank unit consists of

either 8 or 10 tanks, a sump, and a 9-in. (22.8-cm.) vertical type centrifugal pump of 1600 gal. per min. capacity. Each bank has an individual circulation of 1600 gal. per min. between it and the sump, while an overflow arrangement provides for the return of such a portion of the electrolyte as is equivalent to reduced solution added. Daily analyses are made of the solution entering and leaving the tank house. Since the operating conditions for the month of March were more nearly uniform for the plant as a whole, the analyses of the solution for this period is given in Table 17. The specific gravity of the solution to the tank house (neutral advance) is 1.310 and of the solution from the tank house (acid advance) is 1.305.

The current efficiency depends on the quantity of ferric sulfate present, due to the reaction between ferric sulfate and metallic copper. The ferric iron content in the solution is kept as low as possible and the conditions shown are as good as can be expected. No doubt with a smaller quantity of total iron present in the solution less would be oxidized, and it was recommended that the total iron be kept below 2 per cent. With the total iron not over 2 per cent., the ferric iron in the electrolyte will probably not exceed 0.5 per cent., the current efficiency will be increased, and more acid will be regenerated.

TABLE 17.—*Analyses of Solution Entering and Leaving Tank House*

	Solution to Tank House Neutral Advance, Per Cent.	Solution from Tank House Acid Advance, Per Cent.		Solution to Tank House Neutral Advance, Per Cent.	Solution from Tank House Acid Advance, Per Cent.
Cu	2.985	2.513	MnO	0.040	0.040
Fe (ferrous)	2.315	1.660	CaO	0.060	0.062
Fe (ferric)	0.085	0.745	P_2O_5	0.130	0.130
Fe (total)	2.400	2.405	Cl	0.0123	0.0110
Al_2O_3	2.470	2.465	H_2SO_4, free	1.70	2.10
MgO	1.360	1.360			

At the beginning of operations in the tank house, a great deal of difficulty was encountered by the dropping of cathodes in the electrolytic tanks, due principally to the corrosive action of the ferric sulfate on the loops at the solution level, and on that part of the cathode covered by the ends of the loops. Corrosion at the solution line was easily remedied by raising and lowering the solution level in the electrolytic tanks, but the corrosion of the cathode sheet between the loop ends was far more difficult to overcome. Later this condition became worse with the increase in the ferric iron and higher temperature of the electrolyte. The

dropping of cathodes not only caused bad short circuits in the tanks but made it necessary, when pulling cathodes for shipment, to pull individual sheets with tongs, which made it almost impossible to handle the daily output of cathodes. Considerable damage was also done to the lead lining of the tanks and the danger from accidents was more than usual. Numerous schemes to overcome this difficulty were suggested and tried, until it was found that by splitting the ends of the loop and attaching them with a Morrow machine in such a manner that the portion of the starting sheet adjacent to the loop was exposed to the deposition of copper, not only the loop, but also the sheet built up, making a good firm joint. Since the adoption of this method no further trouble has been experienced with dropping sheets. Patents have been applied for and allowed covering this improved loop.

The average weight of copper per kw. hr., gross a. c., for the first year was 0.70 lb. (0.3 kg.). It is expected that it will be increased to 0.80 lb. for the coming year.

Since the oxidation of the ferrous sulfate diverts oxygen from the formation of acid, the actual acid regenerated is only about 65 to 70 per cent. of the theoretical. This again shows the importance of keeping down the oxidation to the minimum. This could be done by increasing the flow of solution through the tank house to the permissible limit, or by reducing the quantity of total iron in the solution.

It was originally recommended that the electrolyte be filtered before entering the tank house, with the idea that a purer electrolyte would give better cathodes and starting sheets; this was not done. During the first 6 or 7 mo. the solution coming off the ore went directly to and through the tower into the tank house. As the density of the solution increased more slime was carried from the leaching tanks to the tank house and the quality of the copper produced deteriorated. During November it was decided to settle the solution and one of the leaching tanks was converted for this purpose. This settling, crude as it is, produced a notable difference in both the chemical composition and the physical character of the copper.

Some trouble was experienced in the tank house from anode gases. This was remedied, in the usual way, by keeping a small quantity of oil on top of the electrolyte.

When there was practically complete reduction of the ferric iron in the solution entering the tank house, annoyance was experienced by sulfur dioxide being given off from the solution as it entered the tank house. During this time the free acid in the electrolyte was kept at 3 per cent. and was added prior to the entrance of the solution to the tank house. On adding the acid to the return solution from the tank house, this trouble practically ceased. The tank house was started on June 1,

1917, and has been in continuous operation since that time. On June 18, the first electrolytic copper was shipped.

A summary of the tank-house data for March, 1918, is shown in Table 18.

Adjoining the tank house on the west is the power house. This was designed by C. C. Moore & Co., of San Francisco, and is a structural steel building 200 ft. (60 m.) long, 126 ft. (38 m.) wide. Five 822.6-hp. Sterling boilers equipped with economizers and automatic fuel-oil control generate the steam. The steam, at 240 lb. (108 kg.) pressure and a total steam temperature of 520°, is delivered to one of two turbo-generators with a normal rating of 7500 kw. each. Either of these generators is capable of handling the entire plant load. Each exhausts into a Wheeler surface-type condenser. The circulating water used for the condensers is cooled by means of a 150 × 400-ft. spray pond. By drawing water for the leaching plant from this spray pond, the salts and incrusting solids are prevented from accumulating.

All power generated is delivered to the station buses, which are enclosed in a concrete structure. Leading from these buses are ten 2300-volt feeders, the three largest carrying power to three Westinghouse motor-generator sets, each consisting of a 2400-hp. synchronous motor, direct-connected to two 170-volts, 5000-amp. d. c. generators, which furnish the current for the tank house, while the seven smaller feeders supply a. c. current which is used by the crushing, leaching, and reduction plant, well, mine, and townsite. About 600 bbl. of oil are consumed by the plant per day. This is supplied through a 6-in. oil line from two steel tanks 60 ft. in diameter by 30 ft. high, each with a capacity of about 15,000 barrels. The average kw. hr. per barrel of oil for the year has been 314.2. The oil used at the plant will average 18,766 B.t.u. per pound of oil.

TABLE 18.—*Tank-house Operation, March,* 1918

Total pounds of electrolytic copper produced	3,152,800
Total pounds of electrolytic copper shipped	3,134,500
Per cent. of total copper shipped as scrap	3.9
Average weight per cathode, pounds	130
Total gross kw. hr., a. c., charged to tank house	4,141,763
Average pounds of copper produced per gross kw. hr., a. c.	0.76
Average temperature of air in tank house	61.5° F.
Average temperature of solution entering tank house	86.5° F.
Average temperature of solution leaving tank house	93.4° F.
Average current density, amperes per square foot of cathode	7.56
Average drop between anode and cathode, volts	2.08
Average advance through tank house, gallons per minute	1300
Average number of tanks on cathode copper	127
Average number of tanks on starting sheets	25

Average number of tanks to discard	20
Average per cent. copper in solution entering tank house	2.99
Average per cent. copper solution leaving tank house	2.52
Average per cent. ferric iron in solution entering tank house	0.09
Average per cent. ferric iron in solution leaving tank house	0.75
Average per cent. total iron in electrolyte	2.40
Average per cent. free acid in solution entering tank house	1.7
Average per cent. free acid in solution leaving tank house	2.1
Average specific gravity of solution entering tank house	1.310
Average specific gravity of solution leaving tank house	1.305

Discard for Purification of Electrolyte

As previously mentioned, only about 45 to 50 per cent. of the total acid used in an 8-day leach is utilized in dissolving copper. The remainder is used in dissolving impurities. If copper only is removed from the solution, the other substances will gradually accumulate and the solution will reach a condition where it will become sluggish in dissolving the copper from the ore. To keep the solution active, it is evident that a portion must be discarded and replaced with fresh water. The quantity of solution discarded per day must contain impurities equivalent to the amount dissolved per day, if the accumulation is to be avoided. In the experimental work it was found that, under similar conditions, nearly all the substances that went into the solution were present in a fairly constant ratio to one another. Of the various impurities dissolved, iron is the most easily and quickly determined and was used as the indication of the quantity of solution necessary to be discarded. Our experimental work clearly demonstrated that the best results are obtained when the total iron in the solution does not exceed 2 per cent. and the specific gravity does not exceed 1.28. To maintain the most efficient conditions, 90 gal. (340 l.) per min. discard was reported as necessary. This was later proved to be correct for conditions in the 5000-ton plant, as shown by the summary in Table 19.

The most economical solution to discard is that containing the greatest quantity of impurity and the least quantity of free acid per unit of copper. For the first 7 months of operation, neutral advance was the most desirable to discard. This solution averaged 3 per cent. copper, 0.2 to 0.5 per cent. free H_2SO_4, and 2.4 per cent. total iron, of which 0.6 to 0.8 per cent. is present as ferric iron. An attempt was made to precipitate the copper from this solution on heavy scrap, but the action was very sluggish. In addition to this difficulty, the launder space designed to treat 30 gal. (113 l.) per min. proved to be insufficient. As the cost of producing cement copper is about 2 c. more per pound than that of electrolytic, it was of prime importance to reduce this amount to the minimum. Since when using neutral solution for discard nearly

one-third of the total copper production would be produced as cement copper, an investigation was made to produce a solution containing the greatest amount of impurities per unit of copper. During December, four electrolytic banks of 10 tanks each were connected in series and

TABLE 19.—*Discard Solutions*

	Gallons per Minute for 24 Hours	Specific Gravity of Solution	Total Iron in Solution, Per Cent.	Average, Days, Leaching Period	Number of Charges Excavated
May, 1917	none	1.15	0.34	9.3	3
June, 1917	none	1.24	1.60	16.1	14
July, 1917	21	1.35	2.36	13.9	18
August, 1917	50	1.38	2.60	12.0	17
September, 1917	90	1.38	2.56	10.5	23
October, 1917	83	1.36	2.44	9.9	23
November, 1917	80	1.34	2.36	9.5	23
December, 1917	70	1.33	2.38	9.3	25
January, 1918	72	1.32	2.26	7.8	28
February, 1918	73	1.31	2.39	9.3	24
March, 1918	75	1.31	2.40	7.2	32
April, 1918	82	1.32	2.49	7.3	29

the effluent from the last bank of tanks was sent to the iron precipitation launders. The average analyses of the solution through each bank of tanks, with a flow of 73 gal. per min., was as shown in Table 20.

TABLE 20.—*Solutions in Iron Precipitation Tanks*

	Copper, Per Cent.		H_2SO_4, Per Cent.		Ferric Iron, Per Cent.		Average Current Efficiency, Per Cent.
	In	Out	In	Out	In	Out	
First bank	3.14	2.72	0.95	1.64	0.45	1.06	73.0
Second bank	2.72	2.30	1.64	1.93	1.06	1.51	55.0
Third bank	2.30	2.06	1.93	2.23	1.51	1.71	46.0
Fourth bank	2.06	1.71	2.23	2.62	1.71	1.82	47.0
All banks	3.14	1.71	0.95	2.62	0.45	1.82	

The results will vary with the amount of solution flowing through the tanks. The action of the effluent from the last bank of tanks was anything but sluggish and the precipitation was rapid. However, the high iron consumption and the low power efficiency made this arrangement

doubtful economy and two of these banks were put on regular tank-house practice. This discard solution, containing a certain amount of free acid, precipitates copper more rapidly than a neutral solution. The cement copper so produced is easily washed from the scrap iron. This method of discarding solution produces a smaller amount of cement and a greater amount of electrolytic copper.

Recovery of Copper from Discarded Solution

The original cementing equipment consisted of six sections of reinforced-concrete launders. These are arranged in two parallel rows of three sections each. They are each 60 ft. (18 m.) long, 10 ft. (3 m.) wide, and 4 ft. 6 in. (1.37 m.) deep, giving a total launder capacity of 16,200 cu. ft. (458 cu. m.) or 121,500 gal. (459,857 l.). The bottom of each launder slopes toward three side cleanout gates. The scrap iron rests upon a grated wood floor. The solution flows through each one successively, but may be by-passed to allow the cleansing and refilling of any of the sections. From these launders the waste solution was to go to the desert.

The launders provided to handle the solution were found to be insufficient and the scrap iron was too coarse for good work. Only about 65 per cent. of the copper in the solution was precipitated during the first 3 mos., and the effluent from these launders was impounded in large ponds and later pumped back to the new launders. The construction of eight additional temporary wooden launders was begun, lighter scrap iron was bought, and the copper content of the waste solution was thereby reduced. Of the eight temporary wooden launders, one is 14 ft. (4 m.) wide, 280 ft. (85 m.) long, and 2½ ft. (0.75 m.) deep, and seven are 10 ft. (3 m.) wide, 280 ft. long, and 3½ ft. (1.05 m.) deep. These have a total capacity of 78,400 cu. ft. (2218 cu. m.), or 588,000 gal. (2,225, 580 l.), thus giving a total capacity of both concrete and wooden launders of 94,600 cu. ft. (2677 cu. m.) or 709,500 gal. (2,685,457 l.). The wooden launders are connected with the concrete launders by a 6-in. lead pipe line.

Under good operating conditions about half the copper is precipitated in each set of launders. When a launder is no longer efficient, the solution to that launder is by-passed and the solution remaining in it is drained. The cement copper in the concrete launders is shoveled out onto wooden platforms, where the iron is hand-picked, and the copper is loaded into box cars for shipment to the smelter.

The cement copper, being practically saturated with ferrous and aluminum sulfates, dries out very slowly. Recently a concrete sump 20 by 75 by 3 ft. (6 by 22 by 0.9 m.) was constructed near the wooden laun-

ders, into which the cement copper can be flushed and washed. A locomotive crane removes the copper in a small bucket to shallow wooden bins, where it is dried for shipment. This part of the process has proved to be a problem and methods are being developed to handle the material more economically.

The solutions entering and leaving these launders during an average month are as follows:

	H_2SO_4, Per Cent.	Copper, Per Cent.	Ferrous Iron, Per Cent.	Ferric Iron, Per Cent.	Specific Gravity
Solution going to concrete launders......	2.34	2.12	1.07	1.44	1.31
Solution coming out of concrete and going into wood launders..................	0.77	0.63	4.51	0.13	1.31
Solution from wood launders to desert...	0.08	0.02	4.54	0.08	1.25

Metallizing Tests

Anticipating the difficulty that will probably be experienced in obtaining suitable scrap iron for precipitation purposes, the company decided to investigate again the plan, first suggested by Mr. Croasdale in 1912, of reducing the iron oxide in calcine to sponge iron. There was no doubt but that this material could be produced and all efforts were directed to devise a furnace for that particular purpose. However, the experiments were brought to a close before this had been accomplished. About this time the experimental staff of the Anaconda Copper Co., working along similar lines, developed a revolving intermittent metallizing furnace of the Brückner type. The results of these tests have been fully described in the *Transactions*.[3]

When we decided again to investigate metallizing, arrangements were made with the Anaconda company to install one of their Brückner furnaces and to furnish us an experienced operator. These tests are still in progress at this writing. We feel convinced, from the results already obtained, that with a high-iron, low-sulfur calcine, nearly complete metallization of the available iron is possible and with coal and oil at a reasonable price, the cost of sponge iron will compare favorably with the present cost of scrap.

At the present time between 20,000 and 30,000 lb. (9071 to 13,607 kg.) of copper are being precipitated per day, with an iron consumption of about 2 lb. (0.9 kg.) per pound of copper. If calcines (metallized) were to be used the principal saving would be in the cost of handling the precipitate.

[3] Frederick Laist and F. F. Frick: *Trans.* (1914) **49**, 691.

Resolution of Cement Copper

It was originally intended to make use of the ferric sulfate present in the oxidized tank-house solution as a solvent of the cement copper, thereby increasing the production of electrolytic copper and at the same time avoiding the handling of cement copper. Cement copper, when clean and finely divided, dissolves readily in ferric sulfate with formation of copper and ferrous sulfates:

$$Fe_2(SO_4)_3 + Cu \rightarrow CuSO_4 + 2FeSO_4$$

By so doing not only is the cement copper dissolved, but the ferric iron is reduced also. The plan was to hose off the loosely adherent copper from the scrap iron to the bottom of the tank and then flush it into one or more circular lead-lined tanks, called agitators. These tanks are 20 ft. (6 m.) in diameter and 6 ft. (1.8 m.) deep, provided with a stirring device, driven by a small motor; 125 gal. (473 l.) per min. of tank-house return solution can be circulated through each tank.

This plan of redissolving the cement copper is only carried out when the operating conditions of the plant require it. The principal objections to the continuous use of such a plan are the difficulty of introduction of the copper to the tanks, the solution dilution that it incurs, and the tendency to increase the impurities, which in turn increase the quantity of discard necessary.

The agitators were started on July 1, 1917, and were continuously operated until Sept. 1, 1917, when it was decided to ship all cement copper possible. During February, the grade of the ore dropped for a short time and it was desirable to increase the copper contents of the electrolyte, and the agitators were once more put into commission. Careful comparison of the present cost of shipping and treating this copper and the cost of redissolving give the latter method a small advantage. In other words, the agitators have not given the results that were anticipated. If, however, a method could be devised whereby the copper could be washed, drained, and then transferred without dilution, it would be a more profitable operation.

Summary

In order that the reasons for some of the present operating conditions may be thoroughly understood, a short account of the events that led to these conditions will be given. Much time having been consumed in the development of the process, the management was eager to begin operations and have this company enter the producing class.

On Apr. 15, the crushers were given a tryout and filling of the leaching

tanks was begun. These were filled with water, both before and after charging with ore, to test for leaks. By May 1, enough tanks had been filled to begin leaching and everything was in readiness except the solution and wash-water pumps. The pumps appeared to be out of balance and much trouble was experienced in the correction. However, by May 16, enough had been accomplished to guarantee continuous operation of the plant. On May 16, 300,000 gal. of 3 per cent. sulfuric-acid solution was made up and pumped on the first charge of ore. This solution was circulated through the first charge the first day, through two charges the second day, and so on each day, more solution being made up to keep the acid concentration at 3 per cent. on the oldest tank.

Unfamiliarity with the piping, leaky tanks, inability of the mine regularly to deliver 5000 T. of ore per day, together with the usual initial operating troubles, resulted in the washing and excavation of only three tanks during May. These conditions rapidly improved, so that over 75 per cent. of the required ore was treated during the first year, and nearly 90 per cent. of the required copper produced in the plant. This was due to the fact that the ore mined averaged nearly 0.1 per cent. better than was anticipated. During this time tanks were not excavated until a new one had been charged and put into circuit, which led to the use of an excessive quantity of acid and accomplished little but the fouling of the solution with impurities.

When the solution carried 2½ per cent. copper, it was advanced to the tank house. By June 1, the electrolytic tanks had been filled and deposition begun. The towers were not started simultaneously with the tank house and by the time of their introduction into the circuit on June 6, the ferric iron had reached 0.7 per cent., the efficiency had dropped, and trouble started.

The first cathodes were drawn on June 15. The solution, clear and of low gravity, produced cathodes analyzing 99.85 per cent. copper. Later as the solution became foul and the density went up to 1.42, the cathodes produced analyzed but 99.1 per cent. copper. The gravity of the solution rose very rapidly and discarding of solution became imperative if the plant was to continue to operate. On July 15, the construction of additional cementing launders was decided upon and as fast as men and material could be obtained these were built and put into operation. Before these launders could be finished, the conditions reached a point where solution had to be discarded irrespective of copper content. The solution coming from the launders was run in a pond and a portion of the copper content was recovered later by treatment in the launders. The first cement copper produced was dissolved in tank-house return solution. This was abandoned for the time being and on Aug. 20 the first car of cement copper was shipped to the smelter.

The original report on the process to be adopted, among other things, recommended that a cooling chamber be installed at the entrance of the gas to the towers. During August, the efficiency of the towers was falling and it was found that a part of the solution coming in contact with the hot gases was evaporated to crystallization, thus choking the gas entrance to the towers. It was then decided to install a cooling chamber. By September, it was realized that the towers lacked reduction capacity and two more would have to be built; these were finished and put into operation Feb. 16, 1918. The fourth roaster was found necessary when the third pair of towers was started. These towers, the cooling chamber, the additional launders, and the wood lining in the leaching tanks represent the only important changes made.

It is reasonable to suppose that with a solution of 1.25 density the extraction, reduction, and tank-house efficiency would be improved. A lighter solution will be a more active lixiviant, the tailings will be more easily washed, less slime will be carried to the tank house, and better cathodes will be produced. The reduction in pumping and repair costs alone might prove to be quite an item.

In conclusion, while the fundamental reactions are simple the attainment of the desired results has been more difficult. Small causes are apt to bring about big results and, as in case of any purely technical operation, the best results can only be secured by the most careful supervision. Neither metallurgically nor mechanically is there anything radically new in the process except that it has been a commercial success from the start.

Appendix

In order to increase the value of the paper the following data, which is a part of the annual metallurgical statement to Jan. 1, 1919, is appended. To give a complete discussion of the noticable changes is not possible at this time. This supplement, however, will be concluded with a short discussion of a few of the more important variations.

Summary of Results

	1917	1918	To Jan. 1, 1919
Total tons of dry ore charged to leaching plant	780,211	1,760,862	2,541,073
Total number of tanks charged	156	355	511
Total copper contents, per cent	1.685	1.465	1.535
Soluble copper contents, per cent	1.632	1.405	1.477
Insoluble copper (probably present as sulphide), per cent	0.053	0.060	0.058
Average proportion of ore on 3-mesh screen, per cent	27.46	26.75	27.01
Average proportion of ore on 4-mesh screen (cumulative), per cent	42.46	43.43	43.13
Average proportion of ore through 20-mesh screen, per cent	18.88	18.43	18.63

Summary of Results—(Continued)

	1917	1918	To Jan. 1, 1919
Total number of tanks excavated	146	355	501
Average moisture in tailings, per cent	11.02	10.73	10.61
Total copper in tailings, per cent	0.371	0.280	0.306
Copper in laboratory washed tailings, per cent	0.270	0.227	0.239
Water soluble copper in tailings, per cent	0.101	0.053	0.067
Average pounds of water soluble copper per ton of tailings	2.02	1.06	1.34
Average number of days leached	10.6	7.59	8.1
Average gallons per minute advance through ore	1020	1139	1095
Circulation in tank, gallons per minute	4500	4500	4500
Average specific gravity of neutral advance	1.360	1.318	1.333
Average free sulfuric acid going on oldest ore, per cent	2.80	2.90	2.86
Average sulfuric acid in solution coming off newest ore, per cent	0.35	0.42	0.39
Average gallons per minute through towers	955	1139	1071
Total iron in neutral advance to towers, per cent	2.34	2.36	2.35
Ferric iron in neutral advance to towers, per cent	1.09	0.84	0.93
Ferric iron in neutral advance from towers, per cent	0.60	0.21	0.354
Roasters in service	3.0	3.9	3.54
Average tons of ore roasted per day	64.2	71.7	69.6
Average sulfur contents of ore, per cent	42.9	42.2	42.4
Average sulfur contents of calcines, per cent	7.8	7.6	7.7
Average sulfur dioxide in gas to towers, per cent	7.63	8.00	7.85
Average sulfur dioxide in gas from towers, per cent	2.44	0.82	1.39
Average sulfur consumed per pound of ferric iron reduced	0.67	0.46	0.54
Average gallons per minute through tank house	955	1139	1071
Average copper contents of solution entering tank house, per cent	2.96	3.12	3.060
Average copper contents of solution leaving tank house, per cent.	2.47	2.71	2.621
Average copper contents removed from solution through tank house, per cent	0.49	0.41	0.439
Average ferric-iron contents of solution entering tank house, per cent	0.60	0.21	0.354
Average ferric-iron contents of solution leaving tank house, per cent	1.08	0.82	0.916
Per cent. of theoretical oxidation	55.9	85.0	73.1
Average current density, amperes per square foot	6.20	7.26	6.91
Average voltage between anode and cathode	1.95	1.98	1.97
Average weight per cathode shipped	130.7	112.4	117.09
Number of tanks on cathodes	116	125.5	122.3
Number of tanks on starting sheets	22.2	26.5	25.1
Number of starting sheets made	155,543	365,547	521,090
Starting sheets scrapped, per cent	11.50	9.56	10.2
Electrolytic copper shipped, pounds	12,661,215	31,745,480	44,406,695
Copper per gross a. c.—kw. hr., pounds	0.669	0.697	
Total acid (60° B. sulphuric acid) charged to plant, tons	40,278.60	63,185.08	103,463.68
60° B. acid per ton of ore leached, pounds	103.2	71.2	82.6
60° B. acid per pound of copper dissolved, pounds	4.03	2.97	3.37
Average per day 60° B., tons	175.10	173.06	173.88
Average copper dissolved per ton of ore leached, pounds	25.62	23.95	24.44
Average total copper dissolved, per cent	77.85	81.17	80.06
Total copper produced as electrolytic, per cent	79.60	77.26	77.93
Total copper produced as cement, per cent	20.40	22.74	22.07
Average copper in cathodes, per cent	99.47	99.49	99.48
Average copper in cement copper, per cent	68.91	54.46	57.23
Average of all solutions going to cementing launders, gallons per minute	65.0	131.3	109.0
Average of copper per day in all solutions going to launders, pounds	29,563	33,956	28,775
Total copper recovered from solutions to launders, per cent	82.05	98.215	93.03
Cement copper shipped as 100 per cent. copper, pounds	3,425,907	11,382,487	14,808,394

The foregoing results show better extraction and better washing for 1918. The per cent. of soluble copper in the tailings will be further reduced by the use of a fifth wash water, which was started on Nov. 9, 1918. Operating conditions during this last year resulted in nearly uniform leaching conditions. The local circulation on the ore has been varied from time to time but 4500 gal. per min. appeared to give the most satisfactory condition. During the past 3 mo. the free acid in the solution going on the oldest ore has been 2.65 per cent. and the extraction has been as good as the average. It now appears that it will be possible to leach with a much lower acid concentration than at first thought necessary. The difference between a 2.65 and a 3.00 per cent. free acid means a saving of approximately 50 tons of acid per day. An acid balance covering the past year's operation indicates that nearly 68 per cent. of the total acid neutralized by the ore was used in dissolving impurities, and 32 per cent. was used in dissolving copper. This statement also shows that of the total acid neutralized by the ore 49.1 per cent. is imported acid, 35.6 per cent. is tower acid, and 15.3 per cent. is regenerated tank-house acid. The total 60° B. acid neutralized per ton of ore for 1918 is 148.6 pounds.

During the year a slight warping of the lead anodes was noticed and these were removed from tanks and straightened, resulting in a better tank-house efficiency. This warping was apparently due to oxidation. To keep the solution from fouling it was necessary to send 109.9 gal. per min. of solution to the precipitation launders. Of this solution 84.9 per cent. was from the tank house, 12.0 per cent. was excess wash water, 2.1 per cent. was tower solution, and 1.0 per cent. was tank-house drainage. During the year the larger part of the copper solution that had been impounded in ponds during the previous year was returned to the precipitation launders and the copper recovered.

During the past year, the plant has undergone no radical changes or alterations. All mechanical equipment, including pumps, piping, and lining have proved satisfactory in both design and material. Plans are being prepared for a new cementation plant, consisting of twelve circular precipitation tanks, classifiers, and filters. This plant is to be spanned by a crane, which will charge the scrap iron to the precipitating tanks. This plant is being designed to handle the copper precipitated mechanically and to thoroughly dry it.

Problems are constantly arising, the solution of which tends to materially simplify operation. These are being investigated in order of their importance and furnish a constant source of interest. The past year has been considered a successful one by all connected with the work and basing our predictions on the experience gained, we predict even better results for the year 1919.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Water-cooled Equipment for Open-hearth Steel Furnaces

BY WM. C. COFFIN,* PITTSBURGH, PA.

(New York Meeting, February, 1919)

THE refractory linings of open-hearth steel furnaces above the bath line are subject to severe wear not only from the heat caused by the combustion of the fuel and the reactions of the bath, but also from the melting action of the gases when not controlled and directed, and from the scouring of the oxides, etc. with which the products of combustion are charged.

The framework that encases or binds the furnace is made up primarily of an iron or steel pan in which the furnace proper is built, side and end buckstays, and tie-rods. The expansion and contraction are so great and variable that the bindings may be subjected to severe stresses unless the tie-rods are carefully adjusted in heating up the furnace, but they are most affected by direct heat and usually become deformed from that cause when the lining is worn thin and, sometimes, when sections of the lining fall in and expose some of the framework.

A deformed framework displaces the skewback of the roof arch and tends to distort or crush the roof. Bent buckstays deform the front wall, causing the door frames to stand away from the lining so that the gases burn between the lining and the frames, destroying both of them. Frequently the frames are attached to the buckstays; then when the latter bend the frames usually break.

Preventing the distortion of the framework and maintaining the economy of the refractories are real factors in the cost of steel making. Not only does the cost of general repairs and reconstruction add directly to the cost of steel produced, but the time lost in making repairs cuts down the steel production and increases the overhead expense of both the furnace shop and its allied foundry or mills.

Many years ago water-cooled equipment applied to iron blast furnaces made it possible to increase greatly not only the size and production of the furnaces but also the life of the lining. It also cut down the loss from frequent repairs. The open-hearth furnace is a much later invention, especially as a commercial factor; for though it dates from the Fred Siemens patent of 1856, much more progress was made in the Bes-

* Vice President, Blaw-Knox Co.

semer process until the latter eighties and most of the development of open-hearth furnaces, especially in large furnaces and aiming for big production, dates from the memory of men still "in the game" and does not go back more than 25 years. Most of the advancement in water-cooled equipment is of even later date and it is within the last 10 years that it has become quite general practice to apply some form of water-cooled device to protect and increase the life of the ports and bulkheads, which suffer most from wear and tear and which require the most attention and expense to maintain.

Cast-iron and cast-steel doors and frames were water-cooled by means of hollow castings in which water circulated and by casting pipe coils in them. These are still used at some plants, but a casting is not a good enough conductor for the water to sufficiently cool the outside surface to protect it, so it is liable to burn out and also to crack and warp. As the heat is very much greater in the ports, other means are necessary to protect them. Quite a few copper-bronze water-cooled castings have been used with some success, but they can be successfully made only in moderate-sized castings and are easily pitted and injured by slag.

Adaptability of Steel Plates for Water-cooled Equipment

Steel plates about 3/8 in. (9.5 mm.) thick can be readily formed into almost any shape desired for water-cooled equipment for doors and frames, buckstays, skewbacks, port coolers, division-wall coolers, bulkhead coolers, etc. If properly designed and flanged to keep the joints from undue stresses, the joints can be welded. Riveting is undesirable both on account of the liability of leaking and because the doubling up of thickness at the joints makes proper cooling impracticable. Steel plates have all the qualities of strength, ductility, and conductivity that make them especially applicable to this use, and they can stand contact with furnace slags and oxides without injury. They are also more free from defects and can be more readily and completely inspected than other materials. The conductivity of steel plates keeps the outside surfaces at nearly the temperature of the water in the device so that if it is in contact with the refractories it has much the same action as coolers in blast furnaces.

In contact with brickwork, which is a very poor heat conductor, the cooling effect will penetrate, at most, about 6 in. (152 mm.) and usually be effective in keeping the brick from softening with the heat for only 4 in. The result is that this type of equipment, if covered a few inches deep, does not have any cooling action on the interior of the furnace and, therefore, does not add to the fuel cost nor cause the furnace to be sluggish. This is at once noticeable with the 4½-in. brick lining on steel-plate furnace doors which forms a slag coating

on the exposed face after thinning down 1 in. or less and will frequently last a full campaign of the furnace run unless jarred out.

About the year 1900, L. L. Knox, of Pittsburgh, Pa., who was engaged in the construction of open-hearth furnaces, began the study of water-cooled equipment and has since devoted most of his time to the development of these devices. With the exception of a few riveted steel-plate doors and frames, he at first designed and installed copper coolers. In 1909, he turned his attention entirely to welded steel-plate devices, which have come into such general use that the latest developments should prove of interest to all engineers in any way associated with the open-hearth steel industry, or who wish to keep up with the growth of its equipment. Many of these devices have a much wider application and are already installed on heating furnaces, soaking pits, copper furnaces, and glass-melting furnaces, and engineers familiar with these various types of furnaces can see where they can be applied to increase the life and reduce the maintenance cost. These devices have been patented by Mr. Knox, with the exception of the Neeland buckstay, which was patented by M. A. Neeland, formerly chief engineer of the United States Steel Corp. They are manufactured and sold outright without any royalties or limitations as to their use.

Illustrations of Water-cooled Equipment

Fig. 1 illustrates an open-hearth steel furnace equipped with water-cooled devices at all essential points, each of which will be referred to separately.

Fig. 2 shows a door and frame, all welded joints of which are kept away from both the back of the frame and the door opening. The back plate is flanged through the door opening and turned back about 2½ in. onto the front plate, which not only takes the welded joint away from the extreme heat but strengthens the door arch, which is subject to stresses from expansion and contraction. The stay-bars and stay-bolts do not penetrate the back plates of either doors or frames, but are welded onto the inside surface before the outside plate is welded; this avoids any possible leaks against the brickwork. Many of these doors and frames have been in continuous use for 3 or 4 years, whereas cast ones seldom last more than a few months. The jambs and arches also last much longer when in contact with these frames and the furnace operators can give the process of melting more efficient attention on account of the cool front.

Fig. 3 shows the doors and frames connected with a direct feed-water line. The raising and lowering of the door is taken care of by a telescopic inlet pipe.

Fig. 4 shows a circulation water system with but one feed-water

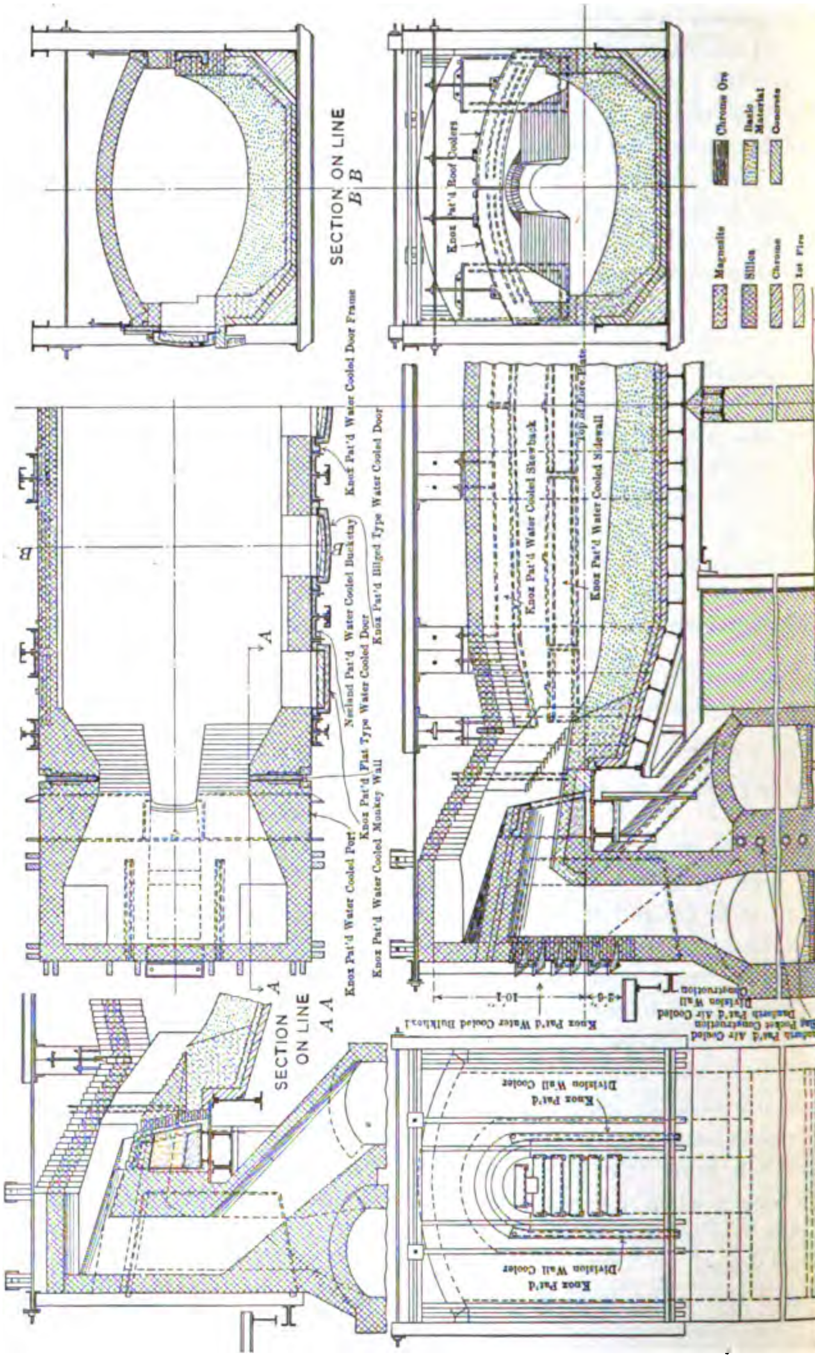


FIG. 1.—OPEN-HEARTH STEEL FURNACE, EQUIPPED WITH WATER-COOLED DEVICES.

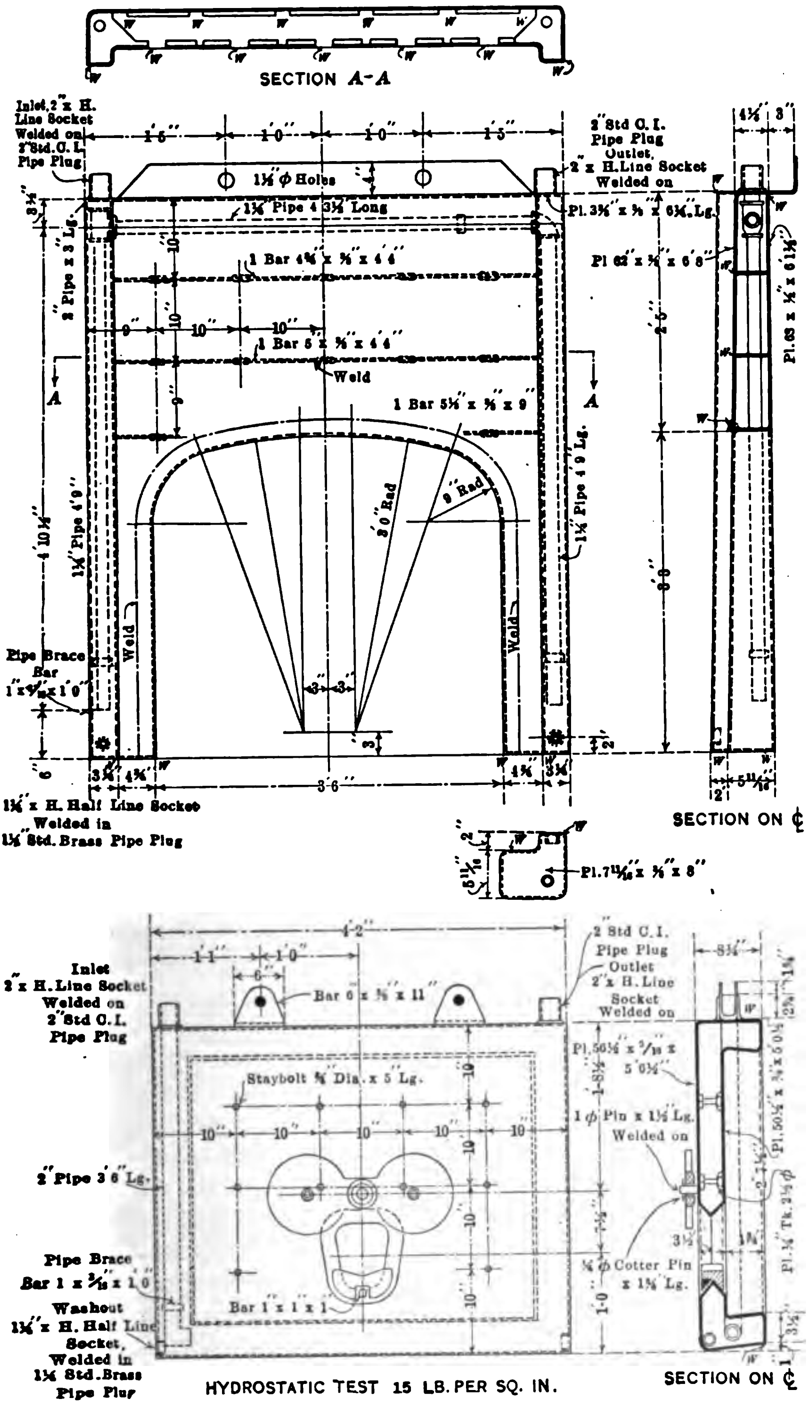


FIG. 2.—KNOX PATENTED WATER-COOLED DOOR AND FRAME.

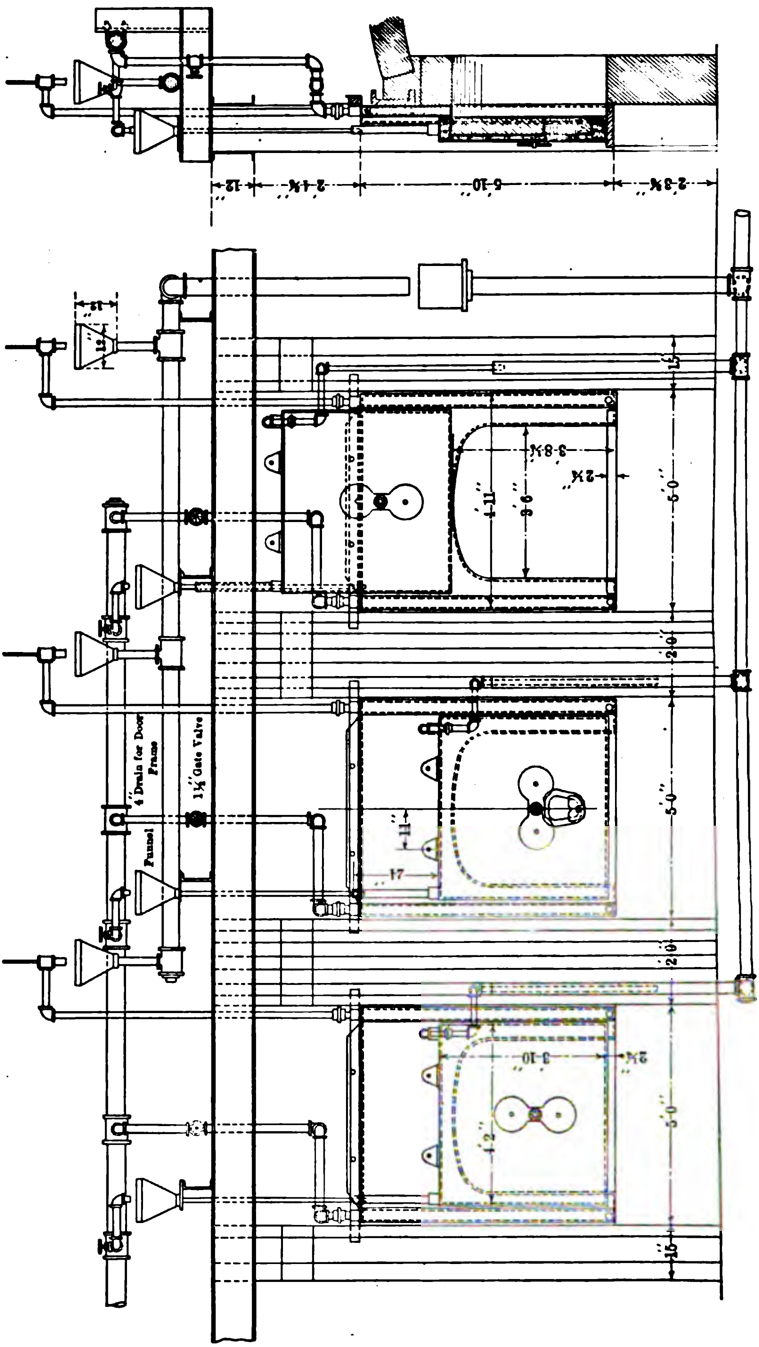


FIG. 3.—DIRECT FEED-WATER CONNECTIONS FOR DOORS AND FRAMES.

connection for the furnace front. This feed line has a nozzle entering a cast-iron ejector on the bottom of the circulation tank, connected with a manifold for feeding the door and frames. The doors are connected with a hose both for inlet and outlet, and the inlet water from both doors and frames is returned to the tank. The overflow from the tank is just sufficient to keep the water from boiling and is usually held at a temperature of about 180°. By having the overflow pipe enter a waste line through an open funnel, the amount of water can always be regulated to suit the requirements by merely inspecting the overflow and seeing that the temperature is neither too high nor too low. The circulation system reduces the amount of water about 30 per cent. below what is used with direct feed, and the circulation tank acts as a reservoir in case the feed water is cut off by accident until either the feed line is repaired or an emergency connection is made with the tank.

Figs. 5 and 6 show a circulation system applied to a tilting furnace, taking care also of chills at the connection between the furnace and the port ends, and of port coolers. Fig. 5 shows the main furnace and Fig. 6 the port end, each with its separate circulation system.

Fig. 7 is a detail of the Neeland water-cooled buckstay, which is also shown in Fig. 1. When used in connection with water-cooled doors and frames, it protects the entire front of the furnace. These buckstays will always keep in alignment; that is, they will not bend on account of heat and, consequently, they hold the skewback of the roof arch in its proper place, with the result that not only is the front wall sufficiently cooled to hold it in place long after it would be burned out with a dry buckstay but the skewback is held in its proper place and relieves the roof from being crushed or distorted.

Fig. 8 shows the port end with the location of the port cooler. This cooler is carried across the port end the full width and both ends of the cooler are exposed; this gives access to the water connections and allows the cooler to be put in place and removed by the charging machine. The charging machine, of course, brings it out only far enough for the overhead traveling crane to get hold of it; when there is no traveling crane, the cooler is placed half way into the furnace with block and tackle and the charging machine pushes it into final position. The port cooler is located at the point where the mixture of the gas and air creates the best combustion, the gas being directed toward the bath. With a dry port, the brickwork is built much nearer the bath than it should be but this is necessary to allow for its wearing away, and it is not rebuilt until it is worn back beyond the point of good combustion. This construction not only makes a waste of fuel, but the lack of control of the direction of the gas causes it to burn both the roof and the side walls. This burning is prevented by the port cooler, as the gas port is held to its proper position and also to its original size, with the result that the furnace works sharply

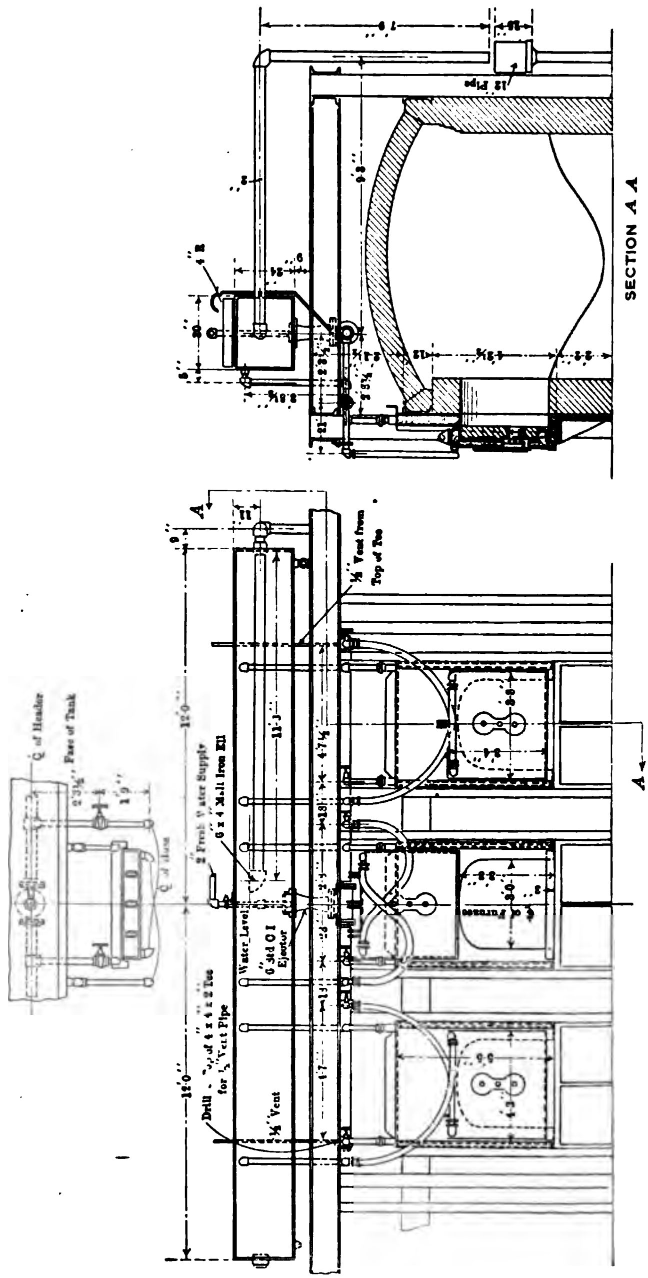


FIG. 4.—CIRCULATION WATER SYSTEM.

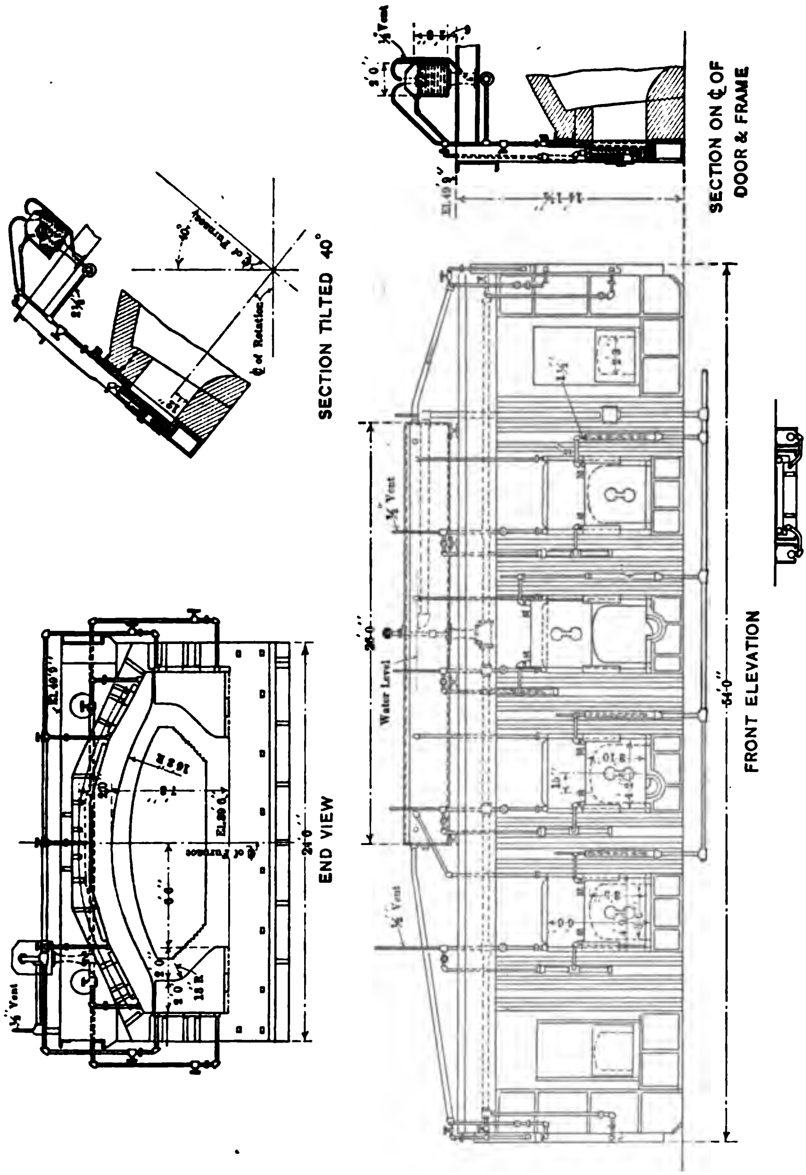


FIG. 5.—CIRCULATION SYSTEM ON A TILTING FURNACE.

and continuously until the checkers become so clogged that the furnace must be shut down to clean them and rebuild at least the top courses.

Fig. 9 shows a detail of the Knox port cooler, which is so constructed that a 4½ in. (114 mm.) brick lining is built in the gas port in a recess, so

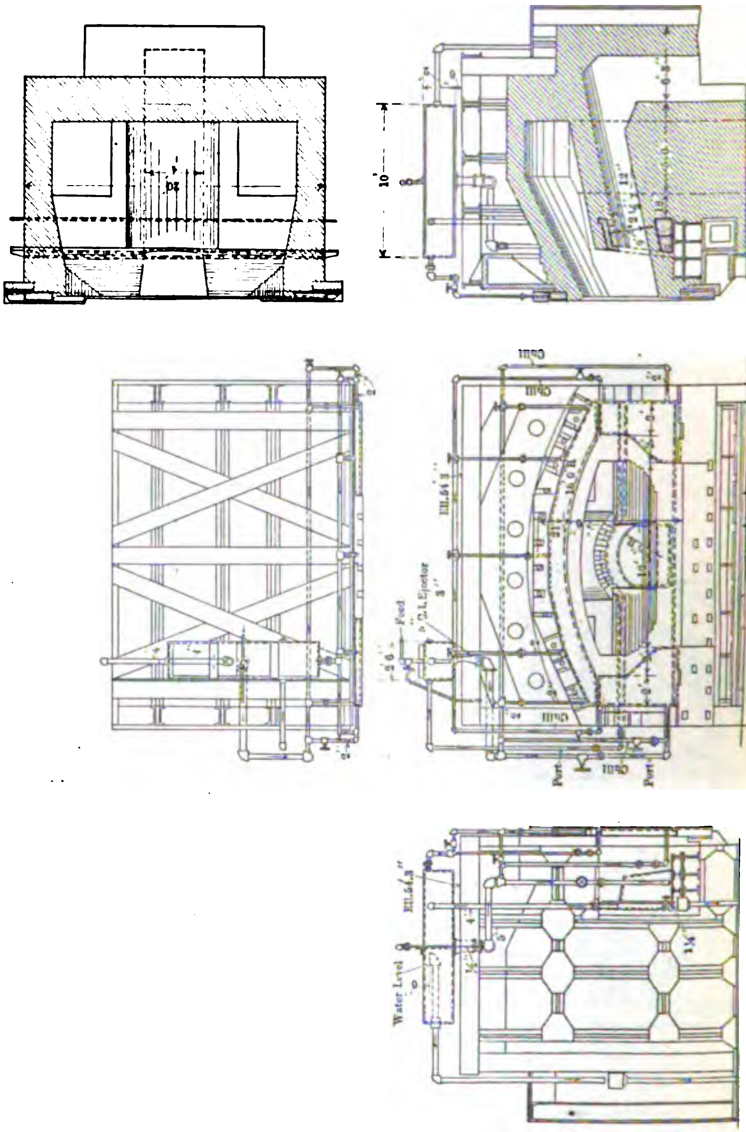


FIG. 6.—CIRCULATION WATER SYSTEM APPLIED TO THE PORT END OF A TILTING FURNACE.

that this lining is protected from being destroyed by the products of combustion. The outlet water is taken by an internal pipe from the highest point of the port so as to use the minimum amount of cooling

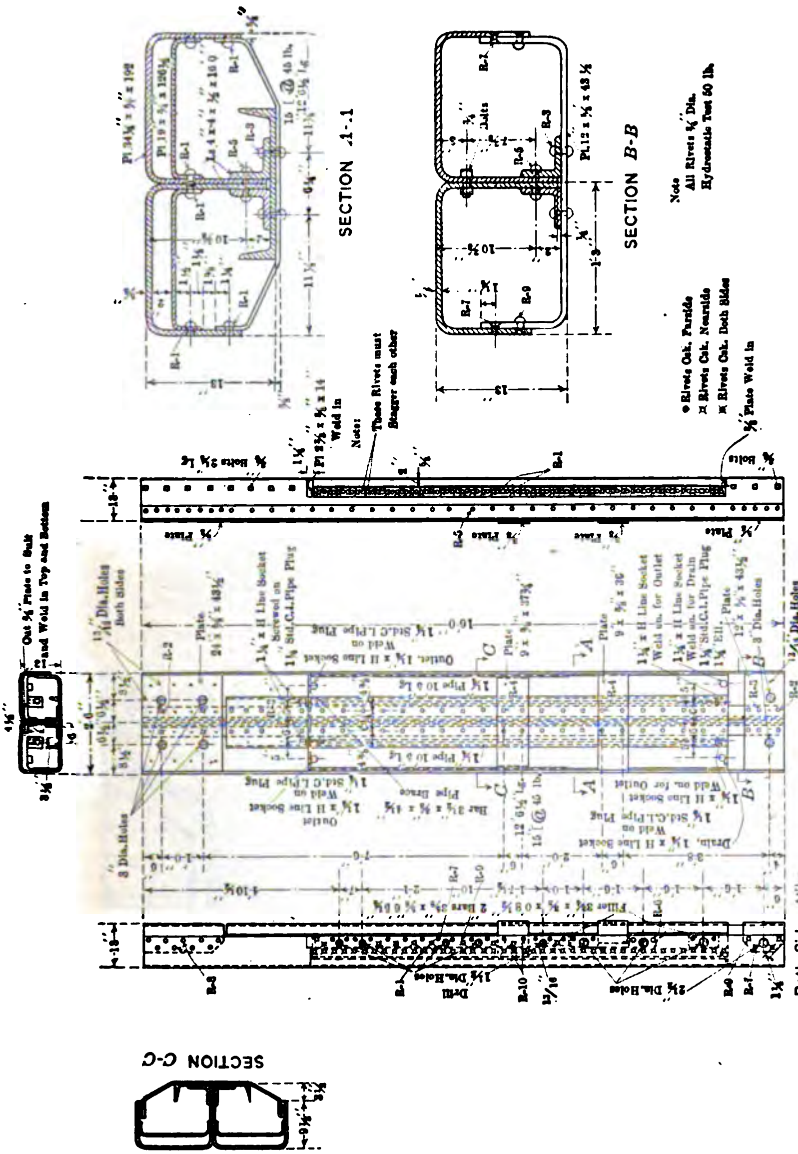


FIG. 7.—NEELAND PATENTED BUCKSTAY.

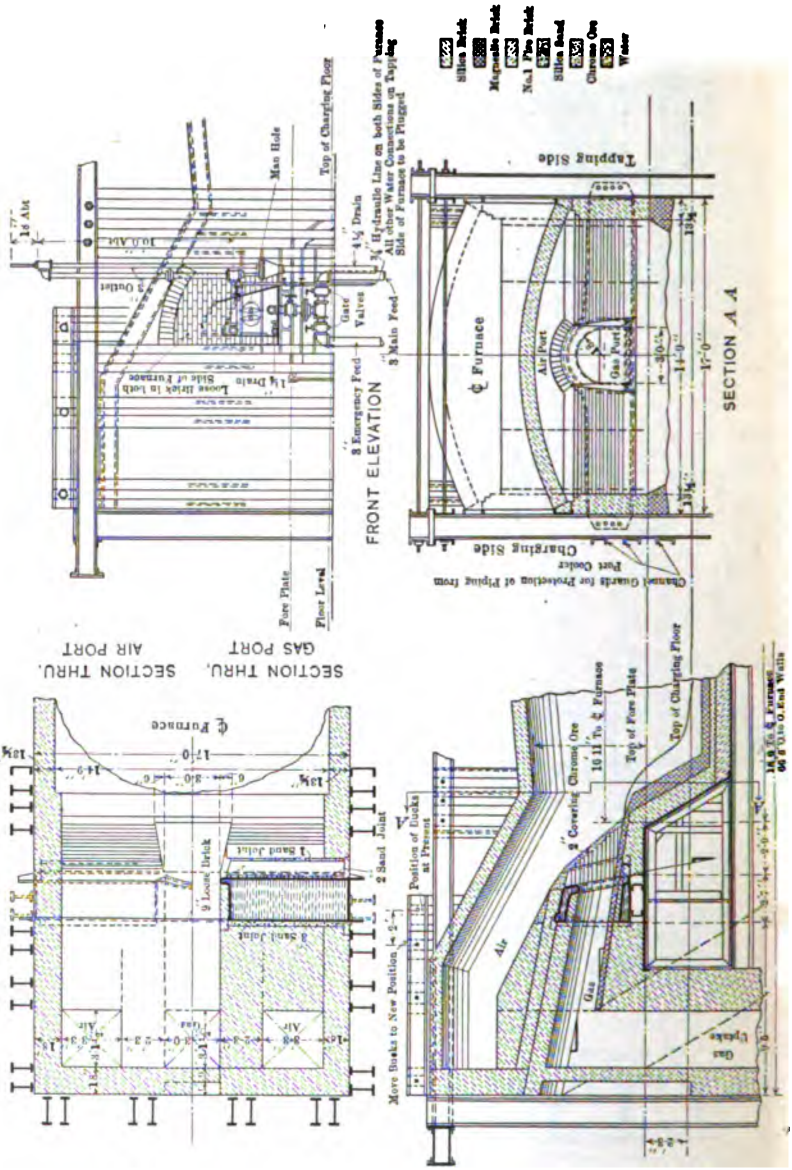


FIG. 8.—PORT END SHOWING LOCATION OF PORT COOLER.

water and make a steam pocket impossible. The port coolers work best with a small head of water, for which reason the outlet pipe is carried up about 6 ft. with a vent on top, so that there can be no siphoning. These pipe connections are shown in Fig. 10. The port cooler has a large chamber in which sediment can settle without any detriment to the cooler, or the working of the furnace. In many cases the coolers, when cleaned during the reconstruction of the furnace or checkers, have been found to contain 8 or 10 in. of mud or coal dust, or whatever impurities the feed water carries. Many of these port coolers have been in use for several years, and have a record of from 1500 to 2000 heats. The design has been improved from time to time and indications are that they will give better service as now constructed.

Fig. 10 shows the coolers in the bulkhead that forms the back wall of the gas uptake. This is subject to a great deal of wear, as most of the heavy oxides and other solids carried over with the products of combustion go through the gas port and impinge on the end wall of the gas uptake. The bulkhead coolers are arranged in a series one over the other, somewhat like bosh plates in a blast furnace. There is a tendency for the division walls between the gas uptake and the air uptakes to either crack or burn out so that the gas and air mix, causing premature combustion. This is prevented by a vertical water-cooled slab or division wall cooler, also shown in Fig. 10.

In order to secure the best combustion in the furnace and also to protect the front and back walls, it is desirable to contract the opening by thickening up the side walls in front of the gas port. This heavy wall is called the monkey wall; frequently furnaces are built without monkey walls because they are destroyed so quickly by the products of combustion. Monkey-wall coolers, which are shown in Figs. 1 and 10, are water-cooled slabs about 2 ft. (0.6 m.) wide and 7 ft. (2 m.) high, which project through the roof. This permits them to be easily placed and removed and also gives access to the water connections. It also forms a seal between the monkey wall and the roof, where the monkey wall first crumbles when it is not protected.

Fig. 11 shows a general arrangement of the Knox gas- and air-reversing valves and Fig. 12 is a detail of this valve. The Knox valve goes back to the first principles, as it is based on a simple vertical damper operating directly in the flues. Other types of valves operate above the flues and require uptakes and downtakes, which reduce the draft usually to 40 or 50 per cent. of the stack draft. They have no means for regulating the draft except by a stack damper, which does not make any individual control of the furnace ports nor a separate control of the gas and air checkers. Each Knox valve is a regulating damper; and when most of the products of combustion go through the gas checkers, leaving the air checkers cold, the gas valve can be opened very slightly, or not

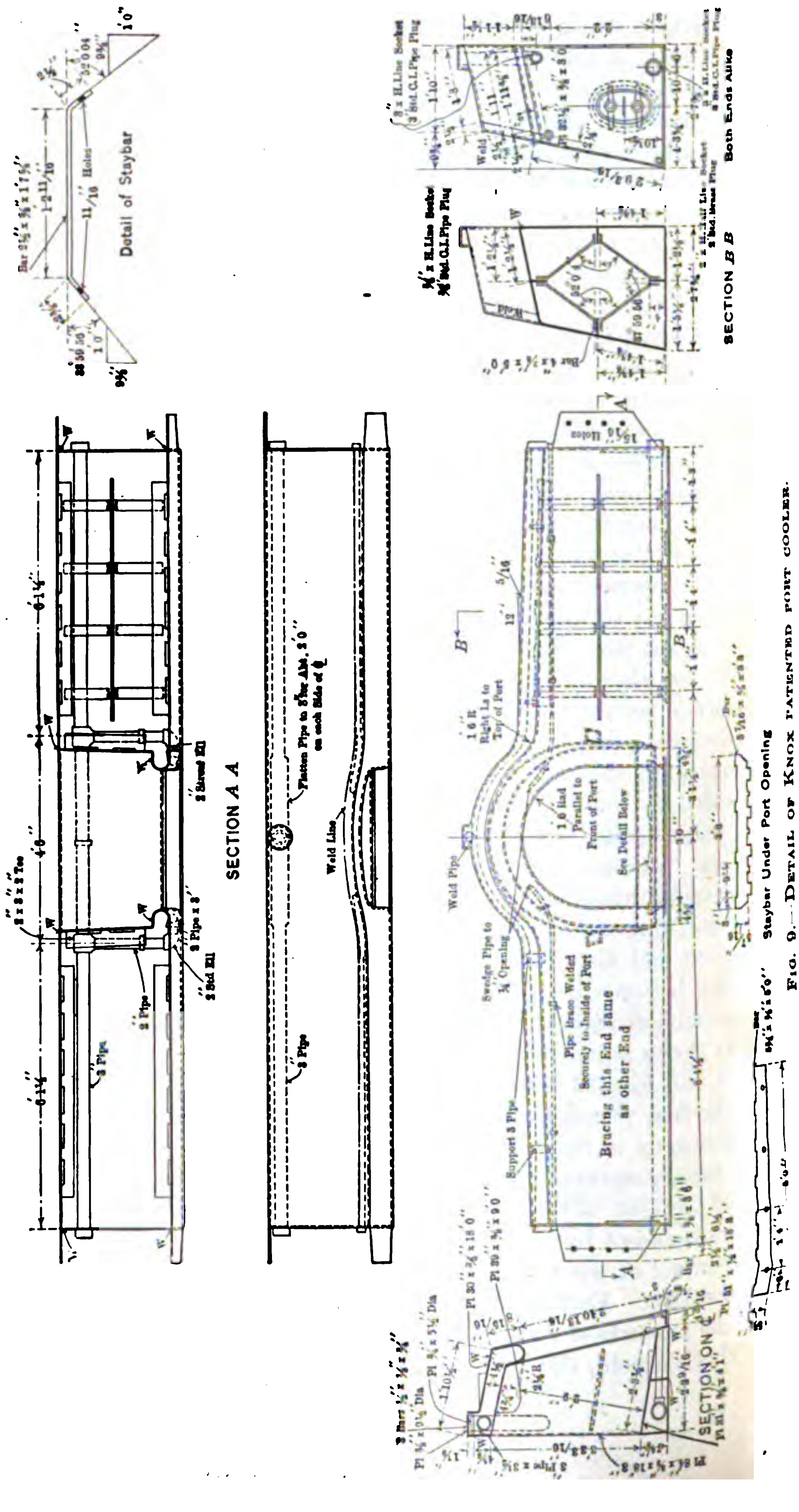


FIG. 9.—DETAIL OF KNOX PATENTED PORT COOLER.

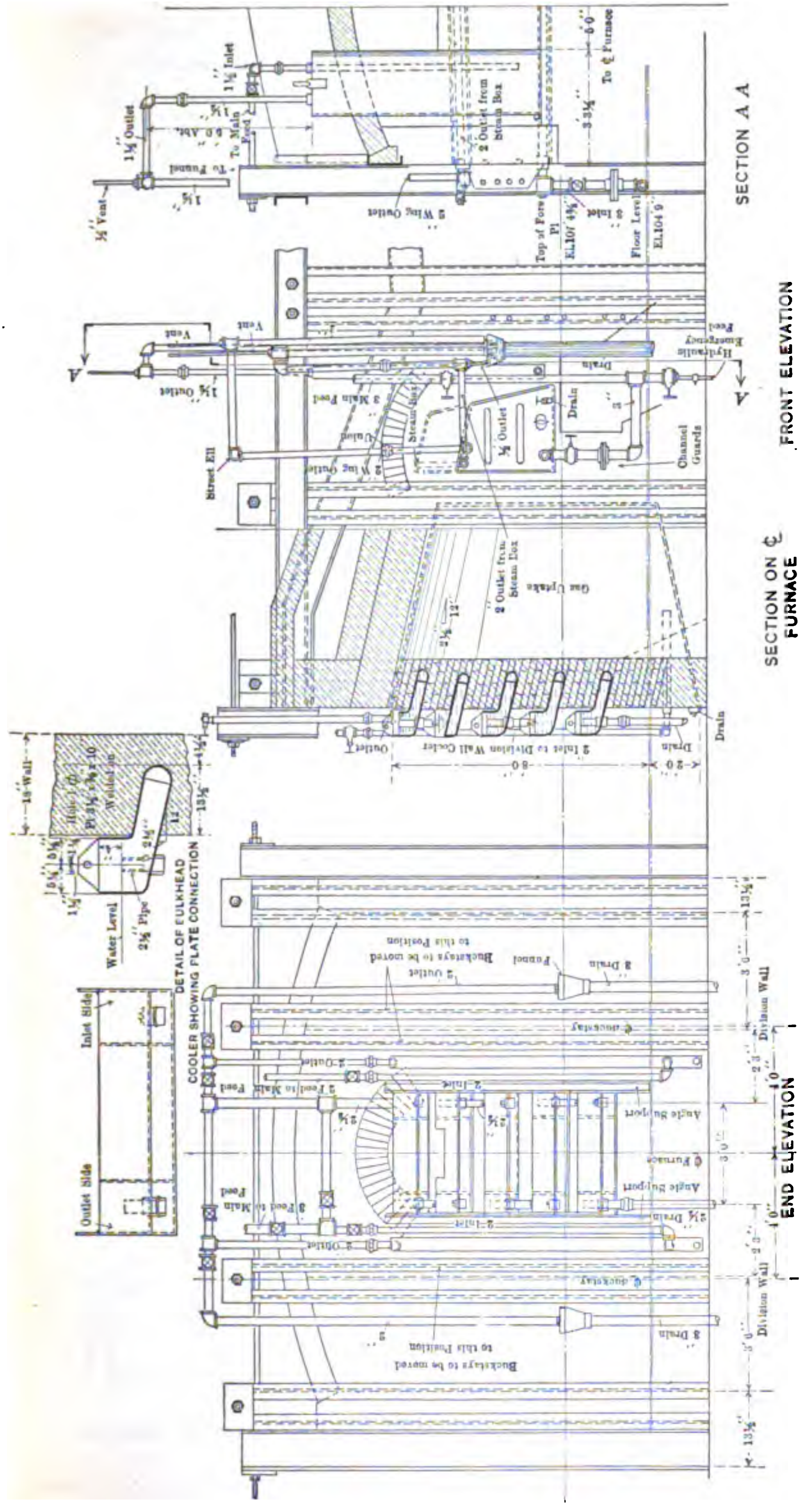


FIG. 10.—PORT END SHOWING BULKHEAD DIVISION-WALL AND MONKEY-WALL COOLERS.

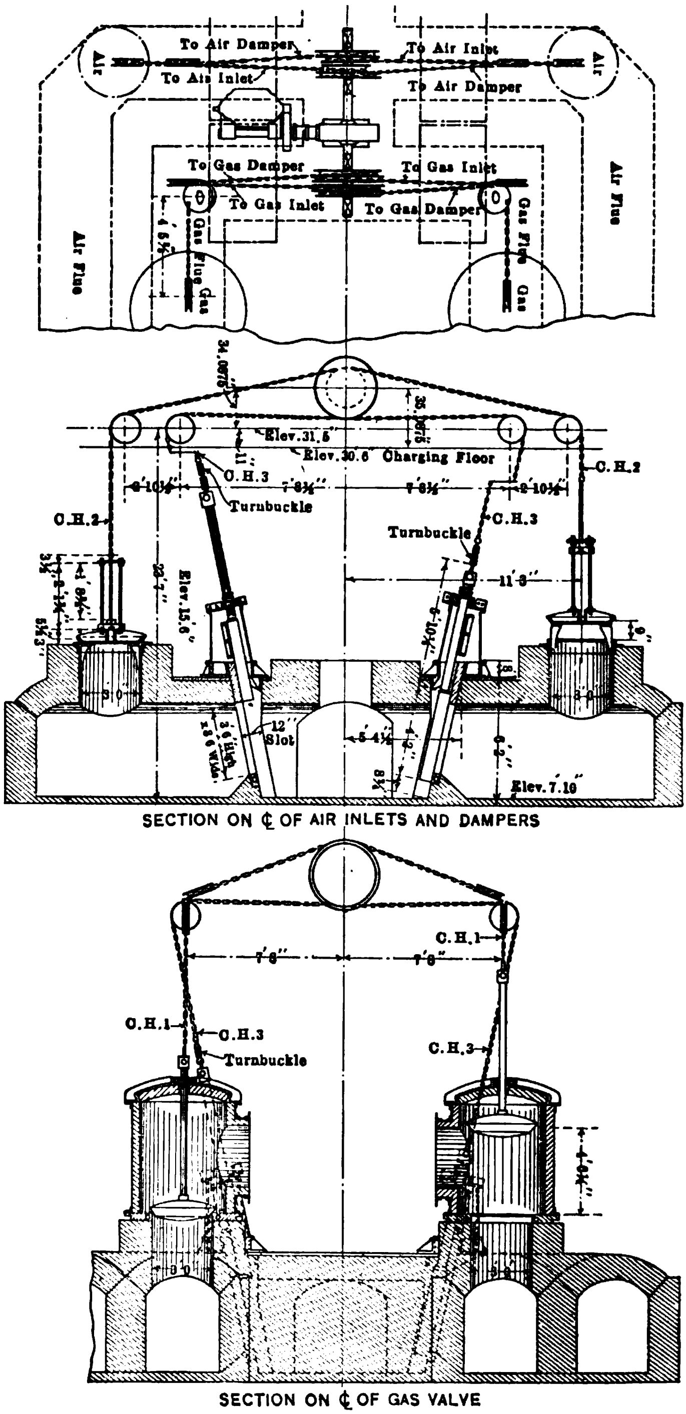


FIG. 11.—ARRANGEMENT OF KNOX PATENTED REVERSING VALVES.

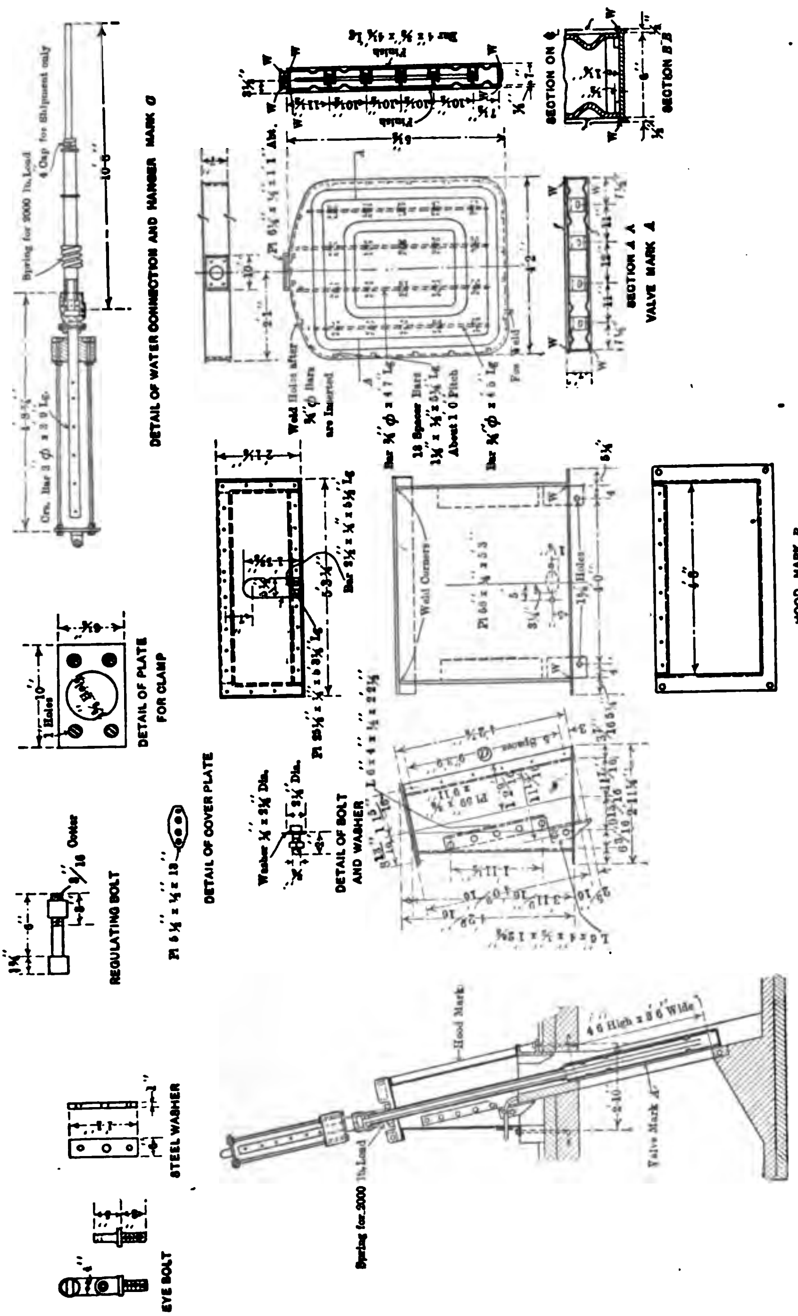


FIG. 12.—DETAIL OF KNOX VALVE.

at all, causing the draft to come through the air checker and heating it. The valves are slightly inclined so as to insure close contact and tightness between the damper and the seat. There was some question as to the effect of tar on the surface of the seat, but it has been found that the tar is only a lubricant, and insures tightness. The valve damper is constructed with a thin steel frame so that the contact between the damper and the seat is narrow, but both the damper and the seat are machined so as to insure flat surfaces. The construction of the damper, with corrugation on the plates, takes care of a slight difference in expansion and contraction between the plates and the outside frame.

These valves are now installed in about 75 furnaces and are a great aid in having the furnaces work sharply, on account of the assured draft and the individual regulation of each chamber. The operating rigging, which is in most cases worked by an electric motor, is so designed that the gas-reversing valves work in a series ahead of the air-reversing valves so that there is no mixture of gas and air, which might cause an explosion, especially when waste-heat boilers are used.

Fig. 1 shows roof-arch coolers, back-wall coolers, and water-cooled skewbacks. These are not in very general use, but have their advantages wherever the operators find that their furnaces are cutting out at these different points.

Although there is a general tendency among managers of American plants to exchange information of value and operators from one plant are usually welcomed at other plants, direct reference to the installation of special apparatus should not be published. For this reason the writer has refrained from mentioning where the several water-cooling devices described are in use. Engineers interested in the general problem will find these devices in almost any plant they may visit and will also learn that the problems to be solved in one plant vary considerably from those in others. The only way to secure the best results is to consider each furnace shop as a different proposition, so that the cooling devices may not only be installed where they are most needed, but that the details are made to especially suit their requirements.

Amount of Circulation Water Necessary

The amount of water necessary for circulation will vary not only with the size of the different devices but with the condition of the furnace. It is dependent also on the quality of the water. When the water contains lime or other solids that precipitate when the water is heated, it should at once be determined in the laboratory at what temperature the solids precipitate, and the outlet water should be kept from 10° to 15° below this temperature. This may require using more water but insures a longer life for the equipment and less trouble for the operator in clean-

ing it. If left to the furnace operators, there is usually much water wasted, as their interest is in the steel making and they do not have the time to watch the equipment closely. It is better practice to have a pipe fitter look after the cooling devices to see that the outlet water is as hot as it can safely be used. When the installation is first made, he should give the apparatus very close attention for the first few weeks, starting with more water than is necessary and gradually cutting down the supply. By following this method it will be found that the minimum quantity of water will give the best results. Unless it contains a precipitate, there is no reason why the outlet water should not have a temperature of between 170° and 180°.

Conclusion

As stated at the beginning of this paper, water-cooling devices for open-hearth steel furnaces should in general follow the lines used in iron blast furnaces. They should not, in a practical sense, be exposed on the inside of the furnace nor tend to slow up operations but should only absorb the heat that would otherwise be radiated in the air or be placed where they have a brick covering and keep it hard enough to hold and thus increase the life of the furnace and keep it true to its best lines. The writer has not had the time to incorporate in this paper the history of the development of these and other water-cooled devices; this will make an interesting subject for a paper in itself.

Many plant superintendents have devoted much thought to this subject and have developed equipment or contributed suggestions that have improved the devices herein illustrated and Mr. Knox can never speak highly enough of the help, coöperation, and encouragement that he has uniformly received from managers, superintendents, and engineers.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
[SUBJECT TO REVISION]

DISCUSSION OF THIS PAPER IS INVITED. It should preferably be presented in person at the New York meeting, February, 1919, when an abstract of the paper will be read. If this is impossible, then discussion in writing may be sent to the Editor, American Institute of Mining Engineers, 29 West 39th Street, New York, N. Y., for presentation by the Secretary or other representative of its author. Unless special arrangement is made, the discussion of this paper will close Apr. 1, 1919. Any discussion offered thereafter should preferably be in the form of a new paper.

Welding Mild Steel*

BY H. M. HOBART,† NEW YORK, N. Y.

(New York Meeting, February, 1919)

This paper deals principally with investigations undertaken by the Welding Research Sub-committee of the Welding Committee of the Emergency Fleet Corporation. The general object of the investigations has been to extend the use of welding in the construction of merchant ships and, specifically, to provide a definite basis for obtaining the best economy and efficiency in employing welding in place of riveting in the construction of the hulls of such ships.

Composition of Ship-plate Steel

The chemical composition of the steel employed in such hull construction varies with the thickness of the plates. Through the courtesy of Mr. H. Jasper Cox of Lloyd's Register of Shipping, the following information may be given concerning the kind of steel plate employed in American Shipyards in 1918 for the hull construction of merchant ships.

Lloyd's requirements do not relate to the chemical composition. They require a tensile strength of 58,000 lb. per square inch (40.75 kg. per sq. mm.) for their lower limit and 72,000 lb. per square inch (50.59 kg. per sq. mm.) for their upper limit. For the information of the Committee, Lloyd's obtained from their surveyors at various works data of the carbon content, which is as follows:

Works	Carbon Content for Plates ¼ In. Thick	Carbon Content for Plates 1 In. Thick
A	0.14	0.23
B	0.14	0.25
C	0.19	0.25
D	0.20	0.30
E Upper Limit	0.30	0.35
E Lower Limit	0.24	0.29
F Upper Limit	0.25	0.30
F Lower Limit	0.21	0.27
G Upper Limit	0.25	0.35
G Lower Limit	0.22	0.28

* Report of research under the joint auspices of the National Research Council and the Emergency Fleet Corporation.

† Chairman, Welding Research Sub-committee.

For shapes, Works H employ:
 Shapes about ½ in. thick, 0.24 per cent. to 0.30 per cent. carbon.
 Shapes about 1 in. thick, 0.28 per cent. to 0.35 per cent. carbon.
Small shapes such as:
 2½ × 2¼ × ¼-in. angles, about 0.15 per cent. carbon.
 4 × 4 × ⅞-in. angles, about 0.20 per cent. carbon.

From several tons of half-inch thick (12.7 mm.) plate from the Yard of the Chester Shipbuilding Company, which was employed in making many sample welds in an investigation designated the Wirt-Jones Tests, seven analyses were made at the Bureau of Standards. The maximum and minimum percentages of each of the impurities for these seven samples were as follows:

	Maximum Per Cent.	Minimum Per Cent.
Carbon	0.25	0.24
Manganese	0.46	0.45
Phosphorus	0.043	0.039
Sulfur	0.031	0.027
Silicon	0.052	0.024

For this material the Bureau of Standards reports:
 Yield point, 38,400 lb. per sq. in.
 Ultimate tensile strength, 64,700 lb. per sq. in.
 Elongation in 2 in., 31.5 per cent.

The following manufacturer's data apply to about ten tons of half-inch ship plate supplied by the Worth Steel Company of Claymont, Del., and to be used for testing electrodes:

Chemical Analysis (Ladle Analysis)

Carbon	0.29 per cent.
Manganese	0.37 per cent.
Phosphorus	0.015 per cent.
Sulfur	0.032 per cent.

Physical Properties

Tensile strength—lb. per sq. inch	67,400
Elongation, per cent. in 8 inches	25.25 per cent.

Another lot of about 1½ tons of ½″ and 1″ ship plate kindly furnished to the Committee by the American Steel and Wire Company for the purposes of the Committee's researches was analyzed by the Electrical Testing Laboratories with the following result, four (4) analyses being made for each thickness:

	Maximum Per Cent.		Minimum Per Cent.	
	½ In.	1 In.	½ In.	1 In.
Carbon	0.24	0.28	0.22	0.26
Manganese	0.44	0.53	0.40	0.47
Phosphorus	0.033	0.033	0.028	0.027

The specifications of the American Society for Testing Materials for structural steel for ships (serial designation A 12–16, p. 98, A. S. T. M. *Standards*, 1918) are in abstract as follows:

> Phosphorus (acid steel), Not over 0.06 per cent.
> Phosphorus (Basic steel), Not over 0.04 per cent.
> Sulfur, Not over 0.05 per cent.
> Tensile strength, between 58,000 and 68,000 lb. per sq. inch.
> Elongation, min. per cent. in 8″ 1,500,000/tensile strength.

From the above data we have a good idea of the kind of steel in connection with which it was the Committee's first and specific task to investigate welding.

Two kinds of Welding are under investigation at present:

(1) Fusion Welding.

(2) Spot Welding.

These are totally different kinds of welding. The fundamental difference is that while in Fusion Welding no pressure is employed, the success of Spot Welding is entirely dependent upon the application of both heat and pressure. For the spot welding of thick plates, the required pressure is very great.

The main features of each of these two kinds of welding will now be stated:

Fusion Welding

The term Fusion Welding is employed to cover Gas Welding and Electric-Arc Welding.

Gas Welding is usually effected by simultaneously fusing with an oxyacetylene flame (1) the material at and near the surfaces which it is desired to join, and (2) some material (which is usually similar in composition) in the form of a rod, the tip of which is subjected to the heat of the flame. The oxy-acetylene flame is directed with one hand and the welding rod is manipulated with the other hand. The operation is illustrated in Fig. 1 furnished through the courtesy of the Prest-O-Lite Company.

Electric-Arc Welding may be subdivided into several classes. The two broadest classes are:

(a) Carbon-Arc Welding

(b) Metal-Arc-Welding

In Carbon-Arc Welding, an arc is established between a carbon or graphite electrode (usually a GRAPHITE electrode) and the two pieces of steel which it is desired to join. This graphite electrode is manipulated with one hand and a welding rod is fed into the weld by the other hand. The operation of Carbon-Arc Welding is illustrated in Fig. 2, supplied through the courtesy of The Lincoln Electric Company. The manual

activities in Carbon-Arc Welding are seen to be quite similar to those in Gas Welding. In neither case is it necessary for the material of the welding rod to traverse the arc.[1]

FIG. 1.—GAS WELDING.

In Metal-Arc Welding, we find a fundamental difference in this latter respect, since in Metal-Arc Welding of mild steel, the arc, instead of having a graphite electrode for one terminal of the circuit, is established

[1] Both for Carbon-Arc Welding and Gas Welding, the edges of the parts to be joined sometimes may be so designed as to obviate the need for any additional material; in other words, no welding rod is necessary in such cases.

between a steel welding rod (or welding electrode) and the two steel parts requiring to be joined. The operator in Fig. 3 is employing Metal-Arc Welding to build up an incorrectly machined crank-shaft journal. There is always a distance of a matter of a tenth of an inch (2.5 mm.) or more between the end of the welding rod and the work. This distance is bridged by an electric arc. The form in which the steel exists during its passage from one end of the arc to the other is at present the subject of investigation by several independent experimentors.

FIG. 2.—CARBON-ARC WELDING.

Their conclusions are awaited with interest. The material cannot pass as a continuous liquid stream, since then there could be no interruptions in the metallic circuit and hence there could be no arc. It can pass as a series of liquid drops, and these can even momentarily short-circuit the arc, the duration of the short-circuit being too brief to be apparent to the operator or ordinary observer unaided by special apparatus. Or the drops can be so minute as to be incapable of effecting a short-circuit. If this should be the case, we can conceive of the metal passing as a stream of finely-divided liquid. Still another possibility is that the steel may pass as a highly-heated gas and condense on the opposite surfaces. It is suggested by physicists that, in its passage

through the arc, the steel may undergo instantaneous transformations of which no human knowledge at present exists.

There would appear to be more of these complex possibilities in Metal-Arc Welding than in Gas Welding or in Carbon-Arc Welding. Nevertheless, it is precisely Metal-Arc Welding which is at present proving very attractive to engineers. It is too early to return a verdict as to whether this wide-spread tendency toward Metal-Arc Welding is based on sound premises or whether there ultimately may not be a reaction (for certain kinds of work) back to Carbon-Arc Welding. It may be that there has been undue precipitancy in the general stampede which has taken place from Carbon-Arc Welding (which was the first to be developed) to Metal-Arc Welding, which is a later development.

Spot Welding

Spot Welding, as developed for use in ship construction, consists in bringing into good contact, by hydraulic or pneumatic pressure, over-

Fig. 3.—Metal-arc welding.

lapping portions of the plates or parts requiring to be joined, and in sending through the spot of contact a sufficiently large current to heat the plates or parts at this point to a welding temperature. The weld is effected by the combination of pressure and heat.

Several large spot welders have been built. With one of these (which was an experimental machine), sufficient pressure and current were available to weld together three one-inch thick plates. The usual construction of commercial spot welders for use in shipbuilding is similar in general appearance to so-called Bull-Riveters. The largest spot welder yet built for actual use in ship fabrication has a six-foot (1. 8 m.) gap. This outfit is a large stationary machine to which the steel plates and shapes must be brought. It is planned that Bulk-heads, Frames, Floors, and other parts shall be constructed with it and shall then be transported by cranes to their places in the ship. This six-foot-gap

FIG. 4.—DUPLEX SPOT WELDER.

machine is designed with capacity to weld two three-quarter-inch-thick plates. It provides a pneumatic pressure of 60,000 lb. and a current of 50,000 amperes and welds simultaneously two spots, each of some 1-½ inch diameter, in about 30 seconds. With less current a longer time is required, and vice-versa. This particular spot welder, which is shown in Fig. 4, was built by the General Electric Company and is known as a Duplex Welder. This name is due to the feature that TWO spots are *simultaneously* welded, the current crossing the plate in one direction between two electrodes and then back again between two other electrodes.

Two transformers, one located on each side of the plate, are comprised in the outfit. The arrangement is indicated, diagrammatically in Figure 5, in which:

AA represents the two primaries.

BB represents the two secondaries (which, in the actual construction, have only one turn each).

CC and *DD* represent the electrodes between which the current flows and between which the pressure is exerted.
EE represents the two plates to be joined.

The chief object of this duplex feature is to eliminate the large reactance drop of a conducting loop some six feet long and one foot wide when traversed by some 50,000 amperes of 60-cycle current. This amounts to approximately 25 volts. Mr. J. M. Weed, the designer of the machine, reports the interesting fact that the presence in the gap of the plates to be welded, only decreased the current some ten per cent. This 6-foot-gap machine weighs six tons.

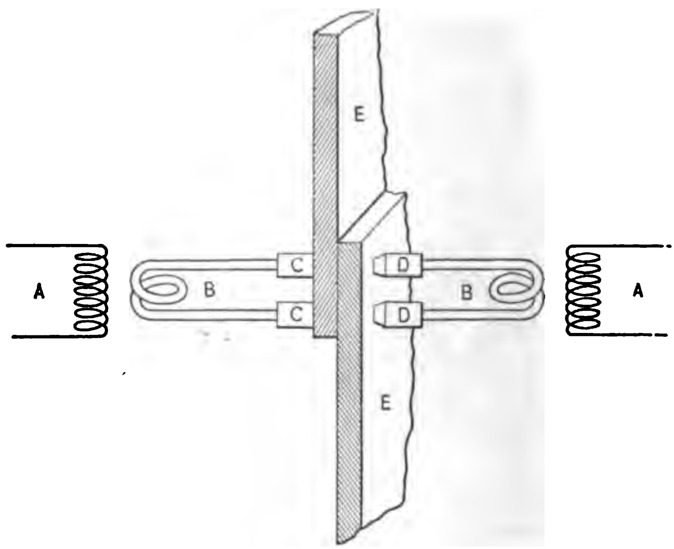


FIG. 5.—WIRING DIAGRAM OF DUPLEX SPOT WELDER.

In some other large spot welders of somewhat reduced size and capacity, the duplex feature is not employed and only one spot is welded at each application of the current. A portable welder of this type (built by the General Electric Company) and having a 27-inch (68.5 cm.) gap, is shown in Fig. 6. This machine weighs only 2800 lbs. (1271 kg.). In this case only one transformer is employed, and the circuit connections are those shown in Figure 7, in which:

A represents the Primary of the Transformer.
B represents its Secondary.
C and *D* represent the electrodes.
E and *F* represent the 2 plates to be welded.

In all spot welders for welding thick plates, the electrodes are water-cooled.[1]

When, in the Spring of 1918, Prof. C. A. Adams, of the Welding Committee of the Emergency Fleet Corporation, appointed several of us to be members of a Welding Research Sub-Committee, we found ourselves facing a task of great interest and importance and of enormous magnitude. It was desired that our investigations should be directed chiefly to the application of welding in the construction of the hulls of merchant ships. Much interior work on ships was already being performed very successfully with Fusion Welding and it appeared strongly

FIG. 6.—PORTABLE SPOT WELDER WITH 27-INCH GAP.

indicated that the time was ripe for the extension of the application to the hulls of ships, with the prospect of producing work not only fully equal (and probably superior) to that obtained by riveting, but also distinctly quicker and cheaper. At that time a welded barge was already nearly completed in England. The Welding Research Sub-Committee ascertained that several American railways had for some time employed Fusion Welding extensively in routine repairs of locomotives and that a matter of possibly a couple of thousand arc welders were at that time employed by American Railways. The extensive and successful use of Fusion Welding for locomotive repairs, in itself constituted strong

[1] Excellent discussions of the subject of spot welding and descriptions of several spot welders built for use in ship construction are given in the four following papers in the *General Electric Review*, December, 1918: Research in Spot Welding of Heavy Plates by W. L. Merrill, p. 919; Spot Welding and Some of its Applications to Ship Construction by H. A. Winne, p. 923; An Electrically Welded Freight Car by Jos. A. Osborne, p. 912; Some Recent Developments in Machines for Electric Spot Welding as a Substitute for Riveting by J. M. Weed, p. 928.

evidence of the ability of such welds to withstand vibration and shock in addition to their proven excellence with respect to tensile strength.

Any doubts entertained by the Committee related chiefly to the question of which of many ways in which it had been demonstrated that good Fusion Welding could be done, was the best way. Furthermore, as regards such mild-steel plates as are employed in the construction of merchant ships, it was soon demonstrated that while sound and quite ductile welds could be depended upon for plates of not over one-half-inch thickness, there was less certainty of good results with plates of greater thickness. But at that time there was no general recognition of the most suitable current to be employed for welding. It was rare to find more than 150 amperes used, even for the heaviest work, and as low as 100 to 125 amperes was found to be frequently employed for welding plates of half-inch thickness.

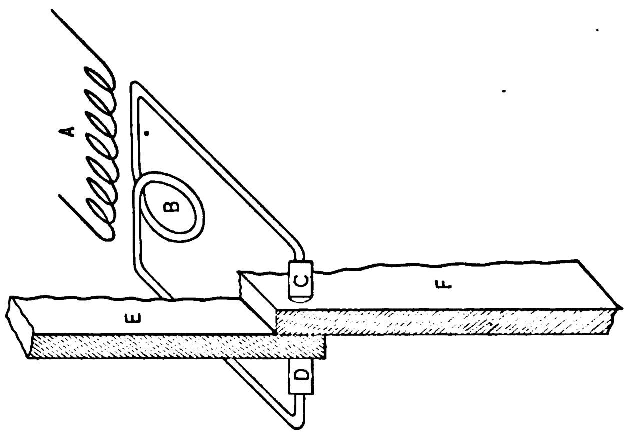


Fig. 7.—Wiring diagram of portable spot welder with 27-inch gap.

It now has been quite conclusively shown that stronger and more ductile welds of half-inch-thick plates are obtained by using at least 200 amperes. The author believes that fully 300 amperes should be used for butt-welding three-quarter-inch-thick plates and a matter of at least 400 amperes for one-inch-thick plates. These are some twice as great currents as have heretofore usually been employed in arc-welding plates of these thicknesses.

In view of this subsequent experience, it is clear that the disappointing lack of strength and ductility in certain welds of thick plates made nearly a year ago was a practically certain consequence of using such small currents.

It would be easy to yield to the temptation to enter discursively upon comments and opinions regarding the many points on which experienced welding specialists hold widely diverging opinions. All these specialists

are producing thoroughly reliable work, but this is not saying that they are all producing nearly as good work as could be produced under the most appropriate conditions for each case. Indeed, the Author's observations lead him to the conclusion that while excellent arc welding is being done on a wide scale, there is a margin for improvement over the present average quality, which, so far as it can be expressed by a sort of resultant of such physical characteristics as:

(a) Bending and Torsion Tests
(b) Tensile Strength
(c) Elongation at Fracture

may be assessed as amounting to at least twenty-five percent.

The author has attempted to make a list of some of the points which are the subject of discussion, and (while usually not going at much length into the questions), to make reference, in some instances, to the views and evidence on each side of a question. It has been the Author's thought that such a summarized presentation might constitute the foundation for an instructive discussion.

The list is as follows:

1. Bare and Covered Welding Wire

The kinds of electrodes advocated and actually used in the art range all the way from the cheapest fence wire, costing but a few cents per pound (say at present prices, some 10¢ per lb.) up to carefully treated and covered electrodes, certain types of which cost over five times as much as bare electrodes. Some makes of covered electrodes are, however, obtainable at reasonable cost (such as, at present prices, some 20¢ to 25¢ per lb.). One type of electrode must yield results uniformly superior to those obtained with another type in order to afford economic justification for a five-times greater price.

2. Salvaging Welding Wire

As to bare electrodes it is generally considered that uniformity is very essential. An operator may be getting along very nicely but will suddenly come to bad places in the welding wire. Heretofore it has been considered necessary to reject such wire. The claim is now made by some people that by merely dipping the electrode wire in suitable material, it may be salvaged. Thus in the Welding Committee's Specification for Electrode Wire (given at page 531 of this paper) occurs a note to the effect that "If electrodes to the above Specification sputter or flow unevenly, they may be dipped in milk of lime (whitewash) before welding. This dipping may be done in quantity on stock on hand and allowed to dry, or the welder may keep a pot of solution on hand into which the electrode may be dipped immediately before welding." This method of salvaging electrode wire was developed by the Schenectady Research Laboratory of the General Electric Company.

Also, it has been demonstrated by Mr. E. Wanamaker that the application, by dipping, of a kind of coating which he has developed (and the precise composition of which he will doubtless contribute to the discussion of this paper), permits of doing good work with electrodes which would otherwise be useless.

3. Preferable Kind of Covering for Welding Wire

With regard to covered electrodes, while some claim that a thin covering obtained by dipping, accomplishes the desired purpose, others

contend that it is desirable to provide a thick covering of appropriate material, which, in turn, is suitably impregnated. Moreover, even for covered electrodes, the usual belief is that the greatest care should be given to the composition and quality of the welding wire to which the covering is applied. In other words, it is not generally held that the use of inferior wire salvaged as indicated under (2), will permit of obtaining the best quality of welds. It is important that the covering shall be so designed as to be consumed at a definite rate as compared with the rate of consumption of the enclosed welding wire. A consequence is that any particular gauge of COVERED welding wire must be used within rather close current limits.

For OVERHEAD WELDING one firm exploiting covered electrodes supplies a special (and additionally high-priced) grade in which the covering is impregnated with a more viscous material than is used for the electrodes which the firm supplies for other welding operations.

4. Preferable Composition for Bare Welding Wire

There is a great diversity of practice as to the preferred composition of bare electrodes suitable for welding mild steel plates. As instances of extremes it may be said that amongst widely used electrodes, while one type consists of almost pure iron, other types have nearly two-tenths of one percent of carbon and one-half of one percent of manganese, and still other types run very much higher than this in manganese. This is quite aside from the subject of special compositions for welding high-carbon steel and for welding cast iron. It is anticipated that quantitative measurements will indicate superiority in tensile strength for some compositions and superiority in ductility for other compositions. Mr. R. E. Wagner has exhibited some very ductile welds made with electrodes containing small percentages of magnesium and of boron sub-oxide.

It is only within the last few months that there have been available any specifications for use in establishing the merits of welding wire. These are now available in the Welding Committee's specification setting forth a "Standard Procedure for Testing Welding Electrodes." This specification, which is given in Appendix A to this paper, was prepared by the Welding Research Sub-Committee in collaboration with Prof. H. L. Whittemore representing the Bureau of Standards and with representatives of manufacturers of welding electrodes.

In Table 1 are given the compositions of various electrodes in current use. Prior to publication, the data in this Table was submitted to the manufacturers concerned, who, in six instances, improved the opportunity to correct the data to conform with their latest practice.

The American Steel & Wire Company has requested the omission from the above Table of any analyses of electrodes which it has furnished

TABLE 1.—*Composition of Welding Electrodes*

Trade Designation of Electrode	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Remarks
Page Steel & Wire Co.						
Armco	0.01	0.025	0.005	0.025	0.005	
Wilson Welders & Metals Co.						
Grade, No. 6	0.15 to 0.23	0.60 to 0.75	less than 0.04	less than 0.04		Also 0.25 per cent. copper.
Grade, No. 9	0.30 to 0.40	about 1.00	less than 0.04	less than 0.04		
Grade, No. 8	0.17 to 0.22	0.30 to 0.45	less than 0.04	less than 0.04		
Grade, No. 17	0.10	0.30 to 0.45	0.06	0.06		
Quasi Arc Co	0.08 to 0.12	0 45 to 0.55	0.00 to 0.06	0.00 to 0.06	0.05 to 0.08	Flux covering of blue asbestos fiber (Crocidolite) enclosing percentage of aluminum or other metal in form of fine wire capable of giving strong reducing action.
Roebling Co	0.16	0.56	0.032	0.024	0.016	
Toncan wire	0.10	0.16	0.01	0.046	trace	
Electric Arc Cutting & Welding Co.	0.25	0.30	0.05	0.05	0.05	
Siemund Wenzel Co	0.10 and under	0.30 to 0.50	0.05 and under	0.05 and under	trace	
Norway-iron Wire	0.05	0.02	0.025	0.007	0.08	
Double Arc Co, of England	0.085	0.35	....	0.054	0.108	Flux covered.
T. Scott Anderson Co., of England.	0.057	0.32	....	0.026	0.014	Flux covered.
E. A. Jones & Co., of England	0.22	0.25	0.001	0.026	0.024	Nickel-plated and flux covered.
Engineering and Equipment Co., of England	0.12	0.51	....	0.08	0.016	Flux covered.
Central Steel & Wire Co.						
Swedox	0.05	0.18	0.04			
The Spencer Wire Co.						
Basic open-hearth steel electrode	0.06	0.12 to 0.20	0.013 and under	0.03 and under		

for arc welding. This is for the reason that material has been supplied to a large number of users, varying considerably in analyses in accordance with the ideas of the purchasers. There does not as yet seem to be an agreement as to the most advantageous chemical composition for electrodes, and the Company is not prepared either from observations of the results obtained by its customers or from its own experimental work to make a definite recommendation.

The Welding Committee has issued the following Specification for Electrode Wire for Electric Welding. The specification was prepared under the immediate direction of Mr. Herman Lemp.

SPECIFICATION FOR ELECTRODE WIRE FOR ELECTRIC WELDING IN CONNECTION WITH MILD STEEL

Welding Committee Emergency Fleet Corporation
REVISED TO DECEMBER 20, 1918

(Note:—This wire may or may not be covered)

1. *Chemical Composition*

Carbon	Not over 0.18%
Manganese	" " 0.55%
Phosphorus	" " 0.05%
Sulphur	" " 0.05%
Silicon	" " 0.08%

2. *Sizes and Weights*

Diameter, in Mils	Diameter, in Fractions of an Inch	Pounds per 100 Ft.	Feet per 100 Lb.
125	1/8	4.16	2400
156	5/32	6.51	1535
188	3/16	9.37	1066

(Allowable tolerance 6 mils plus or minus)

3. *Material.*—The material from which the wire is manufactured shall be made by any approved process. Material made by *puddling process not permitted.*

4. *Physical Properties.*—Wire to be of uniform homogeneous structure, free from oxides, pipes, seams, etc., as proved by photomicrographs.

5. *Workmanship and Finish.*—(*a*) Electric welding wire shall be of the quality and finish known as the "Bright Hard" or "Bright Soft" finish—"Black Annealed" or "Bright Annealed" wire shall not be supplied.

(*b*) The surface shall be free from rust, oil or grease; a slight amount due to lubrication during last drawing is permissible.

6. *Tests.*—Electrodes must, before shipment or after delivery, show good commercial weldability when tested by an experienced arc welder. The electrode material shall flow smoothly in relatively small particles through the arc without any detrimental phenomena.

Note:—If Electrodes to above specifications sputter or flow unevenly, they may be dipped in milk of lime (whitewash) before welding. This dipping may be done in quantity on stock on hand and allowed to dry, or welder may keep a pot of solution on hand into which the electrode is dipped immediately before welding.

7. *Delivery, Packing and Shipping.*—Electrodes shall be furnished in straight lengths of either 14 inches or 28 inches, put up in bundles of 50 pounds or 100 pounds as ordered. Each bundle shall be wrapped in heavy paper securely wired and marked on one end showing diameter in mils, trade name and grade of wire.

5. COMPOSITION OF METAL DEPOSITED IN WELD

A few analyses have been made of chemical compositions of the metal deposited in the weld. Results of the analyses of four sets of electrodes before and after the metal was deposited are quoted below from the Westinghouse chapter in Captain Caldwell's report. To these results are added analyses of Toncan Wire as supplied to the author by Mr. R. E. Wagner.

Analyses of Electrode—Per Cent. of Impurities

	Carbon	Manganese	Phosphorus	Sulfur	Silicon
Roebling..........	0.16	0.56	0.032	0.024	0.016
Norway..........	0.049	0.021	0.025	0.007	0.08
C. R. S...........	0.11	0.72	0.097	0.123	0.011
H. R. S...........	0.13 to 0.17	0.50	0.012	0.045	0.011
Toncan...........	0.10	0.16	0.010	0.046	trace

Analyses of Deposited Metal—Per Cent. of Impurities

	Carbon	Manganese	Phosphorus	Sulfur	Silicon
Roebling..........	• 0.05	0.18	0.031	0.036	0.011
Norway..........	0.05	0.018	0.020	0.072	0.011
C. R. S...........	0.05	0.11	0.086	0.072	0.011
H. R. S...........	0.14	0.14	0.012	0.039	0.011
Toncan...........	0.042	0.081	0.019	0.026	0.000

It is notable that most of the carbon and manganese is burned out in traversing the arc.

6. Polarity

For carbon-arc welding, the standard practice is to connect the graphite electrode to the negative terminal. Mr. Wagner states as his experience that it is very difficult to weld with the carbon arc when the polarity of the carbon is positive. He states it to be almost impossible to direct the heat to the point desired and the welding qualities of the arc under this condition are very poor. He concludes: "Our experience has taught us that it is next to impossible to weld with a carbon arc unless the work is positive and the electrode negative."

For metal arc welding with bare wire, the electrode is usually connected to the negative terminal, but instances occur of bare welding wire which works best when the opposite polarity is employed. Also for some particular sizes and sorts of welds best results are sometimes obtained by a reversal of the polarity. With electrodes heavily covered with flux, the positive terminal is almost always connected to the electrode. Plenty of more or less plausible reasons for these differences have been offered on various occasions. On careful reflection none of these reasons prove particularly satisfying. Amongst other considerations the fact of the entire practicability of arc welding from an alternating-current circuit and of Overhead Welding have to be taken into account in judging some of these explanations. As yet, we have no satisfactory hypothesis as to what goes on in the welding arc.

7. Direct Current Versus Alternating Current for Arc Welding

While up to rather recently it had usually been contended that arc welding required a direct-current supply, there are now many advocates of alternating current.

Mr. E. H. Jones in the course of the discussion of Major James Caldwell's paper entitled "Notes on Welding Systems" read on Jan. 22, 1918, before the Institution of Engineers and Shipbuilders in Scotland, stated: "He would like to take this opportunity of drawing attention to the undoubted merits of alternating current for arc welding. For some reason which he was unable to fathom, the general impression was that direct current was superior to alternating for arc welding, but as a matter of fact he found that alternating current was far superior to direct current, and he would recommend the use of alternating current on every possible occasion. Apart entirely from the capital outlay needed, which was vastly higher in the case of direct current, the control of the current was much easier to effect. . . . He estimated that the amount of current which would be necessary to feed 20 operators with direct current would suffice to feed 28 with alternating current."

Mr. R. E. Wagner's experience is as follows: "Electric welding may be done with alternating current as well as with direct current. It is a little more difficult to hold the arc, but this simply resolves itself into a matter of practice. Men who have been regularly doing arc welding with direct current, very quickly learn how to handle the alternating current arc."

At present there appears to be no agreement as to the applicability of alternating current to Carbon Arc Welding.

8. Periodicity for Alternating-current Arc Welding

Amongst the advocates of the use of alternating current, there is no agreement with reference to the periodicity. Although it is generally maintained that arc welding is only thoroughly practicable with as high a periodicity as fifty or sixty cycles per second, there is, on the other hand, expression given to the opinion that the use of twenty-five cycles, or less, is equally satisfactory. In October, 1918, Mr. R. E. Wagner reported to the Welding Research Sub-committee, that at the Pittsfield Works of the General Electric Co. he had found from his tests that alternating current for arc welding could be used with a frequency as low as 12½ cycles and as high as 500 cycles. Mr. Wagner states that while there is no difficulty at either of these extreme periodicities, the arc is more readily held at 500 cycles than at 12½ cycles.

9. Bare or Covered Electrodes for Alternating-current Arc Welding

While some maintain that arc welding with alternating current is only at its best when flux-covered electrodes are used, it appears to have been conclusively demonstrated by others that excellent results are being obtained under commercial conditions with bare electrodes and an alternating-current supply. A novice can more quickly learn to weld from an alternating-current supply if he employs flux-covered electrodes. But if he can ultimately learn to weld just as rapidly and successfully with bare electrodes, the difficulties in the initial stages of his education should not be regarded as being of much consequence. Mr. Wagner finds that when welding with alternating current, "manipulation may be simplified in many cases by treating the electrode with a thin coating of ordinary lime."

10. Relative Speeds of Alternating-current and Direct-current Arc Welding

Some contend that alternating-current welding is slower. As an instance of a diametrically opposite experience, the following recently received record of test of a certain electrode may be quoted:

"Its operation on 140 amperes, 115 volts alternating current is very good. It also works satisfactorily on 130 amperes, 75 volts direct current, but the metal flows more slowly on direct current than on alternating current."

The record concerning another type of electrode tested on the same occasion, reads as follows:

"This electrode was tried on $\frac{5}{16}''$ plate, 120 amperes, direct current, 75 volts. Its operation is satisfactory. It also works satisfactorily at 140 amp., alternating current, 115 volts, but its operation on alternating current is not quite as good as on direct current."

Mr. R. E. Wagner, who has had much to do with the development of both kinds of welding, states that "on the average the speed of welding with alternating current and direct current are about the same. We have had cases where alternating current is faster and vice versa."

11. Comparative Quality of Arc Welds Made With Alternating Current and with Direct Current

It is contended that the greater difficulty of maintaining an alternating-current arc (involving the necessity of acquiring the skill to hold a very short arc), entails as a consequence that an alternating-current

weld is of superior quality. An experienced observer reports his experience as follows:

"Tests made have demonstrated conclusively that it is possible to do as good, or perhaps better, welding with alternating current as with direct current. No very decided difference has been noticed between welds made with alternating current and those made with direct current, but the welder who did most of the alternating-current welding says that in his opinion the alternating-current welds are better than the direct-current welds. This same opinion has been expressed by the machinist who made repairs on a small tank welded with alternating current. He said that the weld metal was better, more dense, and had fewer blowholes than a direct-current weld."

But an opinion from another authority of great experience in arc welding is as follows:

"As regards the strength of an alternating-current weld there is not the slightest doubt that a greater strength can be gotten on a test piece if that is all the work the man is going to do for some time. The facts, however, are that as the man's hand becomes fatigued in holding the alternating-current arc, his consequent breaking of the arc becomes more frequent, which means less strength in the weld, because every time the arc is broken, a bad spot is left in the weld."

12. Consideration of the Power Factor for Alternating-current Arc Welding

A view presented with considerable persistency is that the low power-factor associated with alternating-current welding leads to capital and operating costs off-setting any advantages. One answer made is to the effect that since for ship welding on an extensive scale, motor-generators are required, this only affects the generator and its circuit and does not affect conditions as regards the motor or the circuit from which it is supplied.

13. Consideration of the Circumstances that Alternating-current Arc Welding is Essentially a Single-phase Load

Similar considerations are involved in regard to the necessity of providing for the characteristics of a single-phase load. It is well known that single-phase motors and generators are much heavier, more expensive and less efficient than polyphase motors and generators. With 30 or 40 arc welding outfits distributed fairly evenly on the different phases of a polyphase system, the load would be sufficiently balanced to be satisfactory, but this would correspond to an unusually large welding

installation. In most cases it will be necessary to arrange for the welding to constitute a single-phase load and to make adequate provision to obtain satisfactory service with this condition.

Regarding the possibility of improving the power factor, Mr. W. S. Moody makes the following very suggestive statement:[3]

"Where a number of arcs are to be used within a reasonable distance of each other, the series system may be used. In this arrangement the secondary of an ordinary constant-current transformer supplies current to the primary of all the welding transformers in series. The individual transformers insulate the welding apparatus from the series circuit and transform from the series current to current of proper value for the arc. In this case the inherent reactance of the series transformer is low, but other features of the design are the same as those discussed above. The power factor of such a system can be safely made much higher than where individual arcs are operated in multiples from constant potential circuits."

14. Spot Welding is a Single-phase Load

Mr. J. M. Weed, who has had a great deal of experience with large spot welders, has kindly written the following paragraph on this subject:

"For welding plates from 3/8" to 3/4" in thickness, the single phase currents required would be from 30,000 to 50,000 amperes and the KVA required at 60 cycles would range between 300 and 900 at power factors of from 0.35 to 0.50. These low power factors, combined with the fact that this load would be for short periods at very frequent intervals would make it decidely undesirable from the central station standpoint. The condition would be much improved at 25 cycles, as the same machine would operate equally as well at 25 cycles as at 60 cycles, with about half the KVA and about double the power factor. The intervals of operation would however, be the same as for 60 cycles. If, however, a motor generator set, with suitable flywheel attached, be provided for operating these machines, these disadvantages are all practically eliminated, this arrangement being such that the motor stores up energy in the flywheel during the interval of no load, the flywheel supplying a large part of the energy during the period of welding. By this means, for instance, a single phase load of 900 KVA at 0.50 power factor for 30 second periods and with intervals of 1-1/2 minutes between periods would be converted to a practically continuous 3-phase load of approximately 200 KVA at about 0.85 power factor."

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[3] *General Electric Review* (December, 1918) 937.

15. Ductility of Arc Welds

Attention has been pertinaciously drawn to results of a very few tests which have appeared to indicate that metal-arc welds are inherently utterly deficient in ductility, yet the Committee has had also before it the results of many well-authenticated tests of ductile metal-arc welds.

It has been claimed that gas welds are more ductile. On this matter Mr. R. E. Wagner writes:

"At several meetings of the Welding Committee, special stress has been brought to bear on the bending qualities of acetylene and gas welds. We have done some experimenting with average acetylene and arc welders, and our impression is, that the acetylene and arc welds are in the same class with respect to bending. I submit herewith (See Fig. 8) a photograph showing comparative bends in acetylene and arc-welded joints, both welds were taken from half-inch plate and both samples were bent under the same conditions, that is, the sharp edge of an angle iron was placed along the weld and pressure applied to the angle iron to make a sharp bend. These, I think are average comparative results. * * * * * * As far as our experiments are concerned, we feel, as regards physical characteristics, that acetylene and arc welds are in the same class."

16. Respective Fields of Gas and Electric Arc Welding

On this subject, under date of Oct. 22, 1918, Mr. R. P. Jackson, of the Westinghouse Electric & Mfg. Co., reports to the Welding Research Sub-Committee as follows:

"With reference to the comparative uses or fields of gas and electric-arc welding which came up at the last meeting, it was thought it might be well for some of us to express our opinions on the matter based on our experience with both kinds of welding. In general, we have found gas welding to be more satisfactory for thin material, say ⅛ inch and under, and for general repair work, particularly where various kinds of steel and cast iron are involved. For example, if repairs have to be made on broken machinery, lugs rebuilt, pieces attached to high-carbon steel and work of this character, then the gas-welding methods are superior and the extra cost not ordinarily prohibitive. When it comes, however, to depositing a large amount of metal and welding up structural steel or plates of ¼ inch thickness and upward, the results obtained by the ordinary direct-current arc with the metal electrode are at least equal to the gas welding work and certainly cleaner. In general, too, the finish of gas welding is more regular and better looking and where that is a consideration it may give a preference to gas. In fact, in the Westinghouse factory at East Pittsburgh, there has been considerably more gas

work done than electric, but the electric arc welding is on the increase, not so much in displacing gas as in displacing riveting."

A view taken from a gas welding publication is as follows:

"The arc process is chiefly used for filling up blow holes in large steel or iron castings and building up worn surfaces which have not to be machined. With this process the results obtained are somewhat uncertain, and it is generally conceded, apart from the vital question of cost, that fusion produced by the burning of gases is to be preferred to the electric process. Welds made by the electric process are sometimes rough, hard, brittle and unworkable—in most cases this is highly objectionable, but not always so. With any fusion method of welding, annealing of the metal adjacent to the weld is desirable. It is impossible to

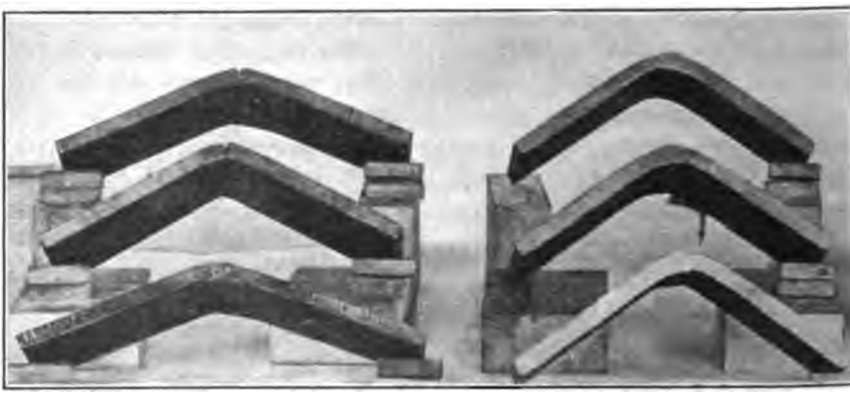

FIG. 8.—GAS AND ELECTRIC BENT SAMPLES. (GAS WELDS AT LEFT AND ELECTRIC WELDS AT RIGHT.)

do this annealing with an electric welder, but with gas welding the blowpipe flame can be used for heating up the metal surrounding the welded part, and also for heating metal away from the weld, so as to counteract any strains that may be set up in the piece as the weld cools off. There are certain classes of work for which electric welding is the most suitable system, and, on the other hand, there are many classes of work where it would be most impractical, and which can be done satisfactorily only with gas welding. For general workshop use, a gas welding outfit is far better, not only because of its greater economy in installation and operation, but also because of its wider range of usefulness."

In the absence of any experience to the contrary this latter view appears fairly plausible, and it is natural that it should have received wide acceptance. But an enormous volume of experience in arc welding has gradually accumulated and it controverts the correctness of the view. Unfortunately the experimental data available on the subject of GAS WELDING is surprisingly meagre. The Welding Research Sub-Committee has concluded that there is practically no test data from

which it can draw any safe generalizations as to the mechanical characteristics of *gas welds*, and that it will be necessary to embark upon its own investigations to obtain suitable data.

Gas Welding was an established art before there was any large amount of electric welding. This was still the state of affairs in England until shortly before the Author was there in the Autumn of 1917. But the War conditions had occasioned in England such a shortage of supplies of oxygen and carbide that the Government, as a War measure, practically forced the wide substitution of arc welding for gas welding. The British Government, in entering upon this policy, had relatively little concern as to the comparative merits of the two methods except in so far as that any merit or advantages found to be associated with arc welding would naturally assist in bringing about its use in place of gas welding.

It was, however, with considerable surprise that it was ascertained that the true economic field for arc welding as compared with gas welding was a very wide one, and that, simply due to inertia and tradition, engineers had been continuing in the contrary belief. Major James Caldwell, of the Admiralty Controller's Department, had wide responsibilities in this task of substituting arc welding as rapidly and generally as possible. Major Caldwell provided the Author with the results of his investigations into the relative costs of gas and electric arc welding. These results, which correspond to conditions in December, 1917, are set forth in the following Table 2.

From Table 2 it is seen that electric-arc welding was found to be a *faster* process for all thicknesses of steel. The British Admiralty results furthermore indicate the economic field for the two methods. The verdict from the data in the Table is in favour of gas welding for thin plates and of electric-arc welding for thick plates. But the comparison is based on the very high cost of electrodes set forth below:

Standard Wire Gauge	Cost in Cents per Foot	Ft. per Pound of Contained Iron Wire	Cost in Cents per Pound
Number 8	3.6	15	54
Number 10	2.6	23	60
Number 12	2.4	35	84

By substituting a typical American price for labour and substituting the cost of bare electrodes, such as are used with entire success in America, in place of the cost of flux-covered electrodes of the expensive type employed in arriving at the results set forth in the Table, the revised results show a lower cost for arc welding than for gas welding for all thicknesses above $\frac{1}{16}$ inch. The question of the quality of the weld is another matter, but judging from the general reputation of the work of

TABLE 2.—*Comparative Costs of Welding by Oxyacetylene and Electric Arc*

Thickness of Metal, Inches	Oxyacetylene: Gas per Hour: Oxygen, Cubic Feet	Oxyacetylene: Gas per Hour: Acetylene, Cubic Feet	Oxyacetylene: Cost for Gas per Foot Run, Pence	Oxyacetylene: Iron Wire for Filling, Pence	Oxyacetylene: Labor per Foot Run	Electric Arc: Power per Foot Run: Volts	Electric Arc: Power per Foot Run: Amp.	Electric Arc: Power per Foot Run: Kw.	Electric Arc: Labor per Foot Run, Pence	Electric Arc: Cost of Electrodes per Foot Run, Pence	Oxyacetylene: Feet Run per Hour	Oxyacetylene: Total Cost per Foot Run, Pence	Electric Arc: Feet Run per Hour	Electric Arc: Total Cost per Foot Run, Pence
1/16	3	2.0	0.116	0.131	0.40	100	30	0.075	0.3	12 in. No. 12 = 1.2	30	0.647	40.0	1.575
1/8	9	6.3	0.77	0.196	0.856	100	75	0.312	0.5	18 in. No. 12 = 1.8	14	1.822	24.0	2.612
3/16	13	9.0	1.72	0.262	1.33	100	100	0.50	0.6	24 in. No. 10 = 2.64	9	3.312	20.0	3.74
1/4	17	13.0	2.70	0.250	1.50	100	140	0.70	0.6	22 in. No. 8 = 3.6	8	4.45	20.0	4.90
5/16	27	16.0	4.21	0.327	1.714	100	110	1.10	1.2	12 in. No. 10, 18 in. No. 8 = 4.02	7	6.25	10.0	6.32
3/8	34	24.0	6.82	0.458	2.00	100	120	1.61	1.61	18 in. No. 10, 24 in. No. 8 = 5.58	6	9.278	7.4	8.802
7/16	41	29.0	9.90	0.655	2.40	100	120	2.00	2.0	24 in. No. 10, 36 in. No. 8 = 8.04	5	12.955	6.0	12.04
1/2	48	34.0	14.50	0.786	3.00	100	120	2.40	2.4	30 in. No. 10, 42 in. No. 8 = 9.6	4	18.286	5.0	14.40

Labor taken at 1 shilling per hour.
Oxygen taken at 1/2 pence per cu. ft.
Acetylene taken at 1 pence per cu. ft.
Iron for filling taken at 0.131 pence per ft.
The above figures are based on the British Oxygen Co. standards.

Labor taken at 1 shilling per hour.
Current taken at 1 pence per B.O.T. unit.
Electrodes, No. 10, 1.32 pence per ft; No. 8, 1.8 pence per ft: No. 12, 1.2 pence per ft.

all sorts done by gas welding and by electric-arc welding, they are both thoroughly reliable. No more exact comparison can be made till we have carried through to completion, really elaborate tests of gas welds in order to permit of making a sound comparison with the large amount of research data already obtained with electric-arc welds.

In response to a request for his opinion as to the respective fields for gas and electric arc welding, Mr. R. E. Wagner, of the Pittsfield Works of the General Electric Co., writes as follows: "The present well-tried field for electric-arc welding is confined entirely to welding plates and forms, and a great deal of work has been done on plates varying in thickness from 1/16 in. to 3/4 in. Up to 1/8 in. plates, the cost of gas and electric welding is about the same. Beyond this, the cost is in favor of the electric process. No difficulty is experienced in machining electric welds made with the metallic electrode. While it is recognized that the electric-welded-in material will not stand bending equal to that of the plate in which it is deposited, it is on the average equal to gas-deposited material in this respect."

17. Relative Ductility of Arc Welds Made Respectively With Bare and Covered Electrodes

By some authorities, ductility is believed to be most readily obtained by employing flux-covered electrodes. On the other hand, the Committee has knowledge of several kinds of bare electrodes of various compositions which, in competent hands, make reasonably ductile welds.

18. Speed of Arc Welding

All sorts of values are given for the speed, in feet per hour, with which various types of joints can be welded. Operators making equally good welds have widely varying degrees of proficiency as regards speed. Any quantitative statement must consequently be of so guarded a character as to be of relatively small use. In general, and within reasonable limits the speed of welding will increase considerably when larger currents are employed. It appears reasonable to estimate that this increase in speed will probably be about 25 to 35 per cent. for high values of current. This increase is not directly proportional to the current employed because a greater proportion of time is taken to insert new electrodes and the operator is working under more strenuous conditions. Incidentally, the operator who employs the larger current will not only weld quicker but the weld will have also better strength and ductility.

On this point Mr. Wagner writes as follows: "I would not say that speed in arc welding was proportional to the current used. Up to a certain point ductility and strength improve with increased current, but

when these conditions are met, we do not obtain the best speed due to increased heating zone and size of weld puddle. Speed may fall off when current is carried beyond certain points."

In a research made by Mr. William Spraragen for the Welding Research Sub-Committee on several tons of half-inch-thick (12.7 mm.) ship plate, the average rate of welding was only two feet (0.6 m.) per hour. Highly skilled welders were employed but they were required to do the best possible work, and the kinds of joints and the particular matters under comparison were very varied and often novel.

However, in the researches carried on by Mr. Spraragen it was found that about 1.9 pounds (0.8 kg.) of metal were deposited per hour when using a 5/32" (3.9 mm.) bare electrode and with the plates in a flat position. The amount of electrodes used up was about 2.7 pounds per hour, of which approximately 16.5 per cent. was wasted as short ends and 13 per cent. burnt or vaporized, the remainder being deposited at the speed of 1.9 pounds per hour mentioned above.

For a 12-foot-cube tank of half-inch-thick steel welded at Pittsfield, the speed of welding was 3-feet per hour. The weight of the steel in this tank was 16,000 lb. and the weight of electrode used up was 334 lbs. of which 299 lbs. was deposited in the welds. The total welding time was 165 hours corresponding to using up electrodes at the rate of just 2 lbs. per hour. The total length of weld was 501 feet, the weight of electrode used up per foot of weld thus being 0.60 lb. The design of this tank comprised eighteen different types of welded joint. Several different operators worked on this job and the average current per operator was 150 amperes.

For the British 125-foot-long Cross-Channel Barge for which the shell plating was composed of quarter-inch and 5/16" thick plates, in Mr. H. Jasper Cox's paper read before the Society of Naval Architects on Nov. 15, 1918, and entitled "The Application of Electric Welding to Ship Construction" it is stated that: "After a few initial difficulties had been overcome, an average speed of welding of 7 feet per hour was maintained, including overhead work which averaged from 3 to 6 feet per hour."

In a report appearing on page 67 of the Minutes and Records of the Welding Research Sub-Committee for June 28, 1918, Mr. O. A. Payne of the British Admiralty states: "A good welder could weld on about one pound of metal in one hour with the No. 10 Quasi-Arc electrode, using direct current at 100 volts. An electrode containing about 1½ ounces of metal is used up in about three minutes, but this rate cannot be kept up continuously."

The Quasi-Arc Co. publishes the following data for the speed of arc welding in flat position with butt joints, a 60 degree angle and a free distance of ⅛ inch.

Thickness of Plates	Speed in Feet per Hour
⅛″	30
¼″	18
½″	6
1″	1.3

I cannot, however, reconcile the high speed of welding ½-inch plate published by the Quasi-Arc Co. as 6 ft. per hour, with the report given above by the British Admiralty that a good welder deposits one pound of metal per hour with the Quasi-Arc electrode. If the rate given by the Quasi-Arc Co. is correct, it would mean that about four pounds of metal were deposited per hour. On this basis the rate must have been computed on the time taken to melt a single electrode and not the rate at which a welder could operate continuously, allowing for his endurance and for the time taken to insert fresh electrodes in the electrode holder and the time taken for cleaning the surface of each layer before commencing the next layer.

From his observations the Author is of the opinion that a representative rate for a good welder lies about midway between these values given respectively by Mr. Payne and by the Quasi-Arc Co., say for half-inch plates some two pounds per hour. This, it will be observed, agrees with Mr. Spraragen's experience in welding up some six tons of half-inch ship plate with a dozen or more varieties of butt joint and Mr. Wagner's results with the eight-ton tank. Even this rate of two pounds per hour is only actual time of welding operator after his plates are clamped in position. This preliminary work and the preparation of the edges which is quite an undertaking, and requires other kinds of artisans, accounts for a large amount of time and should not be underestimated.

The practice heretofore customary of stating the speed of welding in feet per hour has led to endless confusion as it depends on type of joint, height of welt and various details. A much better basis is to express the speed of welding in pounds of metal deposited per hour. Data for the pounds of metal deposited per hour is gradually becoming quite definite. The pounds per foot of weld of metal required to be deposited can be readily calculated from the drawings or specifications. With the further available knowledge of the average waste in electrode ends and from other causes, the required amount of electrode material for a given job can be estimated.

19. Suitable Current For Given Cases

For a given type of weld, for example, a double Vee weld in a one-half-inch-thick ship plate, it was found that while some operators employ as low as 100 amperes, others work with over 150 amperes. Some, in

making such a weld, employ electrodes of only 1/8 in. diameter and others prefer electrodes of twice as great cross-section. For the particular size and design of weld above mentioned, the Welding Research Sub-Committee has had welds made with from 200 to 300 amperes. The conclusion appears justified that the preferable current for such a weld is at least 200 amperes. If the weld of the half-inch-thick plate is of the double-bevel type, some 50 amperes less current should be used for the bottom layer than is used for the second layer, if two layers are used. For three-quarter-inch-thick plates, the most suitable welding current is some 300 amperes. This is of the order of twice the current heretofore most usually employed for such a weld.

Mr. Wagner writes: "We have made a number of tests to determine the effect of varying current on the strength of the weld. Tests were made on a 1/2 in. plate with current values as follows: 80, 125, 150, 180, 220, 275, and 300 amperes. These tests show improvement in the tensile strength and bending qualities of welds as the current increases. The speed of welding increases up to a certain point and then decreases."

20. Effect on Arc Welding of Voltage Employed

Mr. Wagner reports as follows: "We have made a number of tests to determine the influence of variable voltages on the strength and character of electric welds. The experiments were made welding 1/2 in. plate with 150 amperes held constant and voltage varying as follows: 40, 75, 100, 125, 150, 200 and 225 volts.

"This test demonstrates that there is no material difference in the tensile strength, bending qualities or the appearance of the welded-in material. There is this advantage, however, in the higher voltage, that variations in the strength of the arc do not materially affect the value of the current.

"A curve-drawing ammeter was installed on the welding circuit which showed variations in current at 75 volts but at 150 volts the current curve was practically a straight line."

21. Preferable Size of Electrode

On certain railways, a single diameter of electrode is employed independently of the size or shape of the plates or parts being welded. The experience of other people leads them to make use of several different sizes of electrodes according to the size of the job and the type of joint. Present British practice appears to be to use such a size of electrode as to have a current density of some 4000 to 6000 amperes per square inch. The investigations of the Welding Research Sub-Committee are indicating that at least 10,000 to 12,000 amperes per square inch is suitable for electrodes of 1/8 in. and 5/32 in. diameter and well up toward 10,000 amperes per square inch for electrodes of 3/16 in. and 1/4 in. diameter.

22. Automatic Machinery for Arc Welding

Several firms are developing machinery for feeding the electrode automatically. Such machinery appears to be capable of making excellent welds at higher speeds than are attainable by hand feeding.

23. Carbon-arc Welding

With the advent of metal-arc welding there has been a tendency to neglect the carbon-arc method. It is quite possible that this attitude is not justified for not only is there now a definite field where the carbon-arc method is advantageous but developments in the art may greatly extend its application.

It is generally agreed that the carbon-arc method is not applicable to vertical and overhead welding, which is, of course, a serious handicap in ship-hull work. The majority opinion of competent observers (with, however, some emphatic dissenting views) appears to indicate that carbon-arc welding is not as reliable as metal-arc welding in ordinary welding, because:

(a) Carbon is carried into the deposited material thus reducing its ductility.
(b) It is more difficult to obtain good fusion on account of overlapping of deposited metal on the original metal.
(c) It is more difficult to manipulate and thus requires greater skill.
(d) It is a much hotter arc which means greater discomfort to the operator and therefore lower efficiency.
(e) Greater cooling stresses are developed because larger areas of adjacent metal are heated.

On the other hand, it is contended by some that carbon-arc welding can be developed to the point where these objections will no longer exist and thus gain the advantages of this method, the principles of which are:

(a) No preparation of the abutting edges is necessary.
(b) Greater rate of deposition of metal and therefore greater speed of welding, particularly in heavy work.
(c) Probable greater adaptability to automatic welding.

It should be stated that there is very general agreement as to the superiority of the carbon arc over the metal arc for heavy work where strength is not so important, especially cast-iron welding and the filling of holes in iron and steel castings.

24. Preparation of Welding Edges

British practice permits the use of smaller angles when the edges of the plates are Veed, than accords with American traditions. If the smaller angles give welds which are equally satisfactory in all respects, the decreased amount of electrode material required, the decreased consumption of electricity, and the increased speed are advantages not to be overlooked; but obviously the matter requires careful investigation. American practice which, up to recently, has been with a very wide angle, appears to have required the consumption of about twice as great a weight of electrode as British practice with the smaller angle. The urgent importance of determining whether the use of the smaller angle involves any sacrifice in quality is evident. There is already considerable basis for the belief that actually better results attend the employment of a smaller angle of bevel when a suitably large current is used. A shoulder in place of the heretofore commonly used sharp bottom edge of the bevel, also constitutes a material gain not only in the saving in welding material, but also in the quality of the weld.

Mr. Wagner states that at the Pittsfield Works of the General Electric Co. they have long adopted the practice of using a 30-degree bevel for plate edgings and that they find it satisfactory for all thicknesses up to ¾ in. He states that this angle gives sufficient room for depositing the metal, reduces the time to weld and the amount of metal deposited.

In one of Mr. Spraragen's researches, various angles of bevel were used. Although the physical tests have not yet been made we can gain from the following Table 3 valuable lessons on the time, amount of metal, and electricity consumed for these different angles of bevel. The "free distance" in each case was ⅛" and the welding was done in a flat position with 5/32" bare electrodes. In each case the weld had a length of three feet.

25. Quality of Overhead Arc Welding

The British Admiralty regards overhead welding as too inferior and too expensive to be employed when it can possibly be avoided. In America a large amount of overhead welding is done in railway shops and it is claimed that it is simply a matter of training operators to the required degree of proficiency.

26. Number of Layers to be Employed

Good progress is being made in obtaining knowledge of the relative characteristics of welds made with different number of layers and of the most suitable current and the most suitable size and type of electrodes to employ for each layer. The tendency is toward the use of at least two layers for half-inch-thick plates, and three layers for three-quarter-inch-thick plate.

Table 3.—*Time, Metal, and Current used with Welds of Different Bevels*

	Angle of Bevel Used, in Degrees			
	15	30	45	60
Amperes	160.00	145.00	118.00	168.00
Weight of electrode used up (lbs.)	2.56	3.83	4.63	6.63
Weight of metal deposited (lbs.)	1.70	2.55	3.65	5.08
Weight of metal wasted (lbs.)	0.86	1.28	0.98	1.55
Pounds deposited per hour	1.82	1.61	1.82	1.81
Feet welded per hour	3.22	1.90	1.50	1.07
Circuit kilowatts	9.91	9.00	7.68	8.25
Kilowatt-hours per foot of weld	3.10	4.70	5.10	7.70

27. Rigid vs. Non-rigid Methods of Welding

On this question it is more a matter of determining the conditions essential to obtaining good results with whichever of the two methods is most appropriate for each particular purpose.

The term RIGID is applied to the process of arc welding, in which the two parts to be joined by welding are, prior to welding, held rigidly by bolting or clamping or by a series of preliminary tack-welds distributed at various points. The Rigid plan is the most obvious for welding the hull plates of ships but its critics claim that the resultant joints are deficient in ductility due to the presence of internal stresses. It is considered that by suitably arranging the order of welding it is practicable to so distribute the heat as to avoid these stresses. At any rate there are many alternative orders of procedure in making welds by the Rigid method and elaborate researches should be made to ascertain the procedure which will yield the best result.

The Non-rigid Method consists in placing at a slight angle to each other the two plates to be welded. As the welding operation progresses along the seam the angle gradually closes and when the weld is completed the width of the welded seam is equal throughout its extent. Such welds are generally considered to be very free from internal stresses, and hence more ductile.

28. Consequences of Different Lengths of Arc

The metal arc is much shorter than the carbon arc. As a result the metal arc weld has the advantage that there is less opportunity for oxygen and nitrogen to gain access to the weld and so far as relates to this feature the metal arc weld should be better. But with the carbon arc the added metal does not traverse the arc, the tip of the welding rod being held down close to the surface on which it is to be deposited. This may ren-

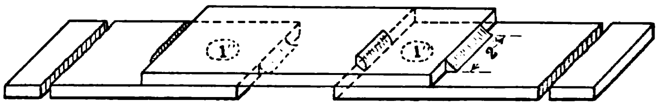

Fig. 9.—Fillet and spot welded.

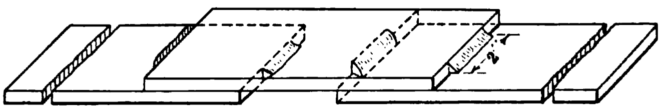

Fig. 10.—Fillet welded.

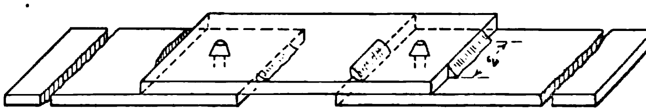

Fig. 11.—Riveted and fillet welded.

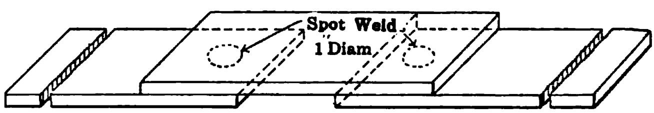

Fig. 12.—Spot welded.

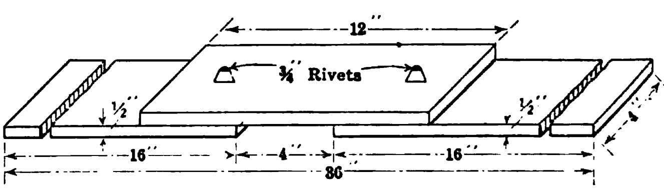

Fig. 13.—Riveted joint.

der the deposited material less subject to contamination in carbon arc welding than in metal arc welding since it has not traversed the arc.

Coming to the exclusive consideration of metal-arc welding, the greater the welding current the less is the area represented by the cylindrical surface of the arc per pound of metal traversing the arc, and consequently the less should be the contamination by oxygen and nitrogen from the surrounding air. So far as this circumstance is concerned, the greater the welding current, for a given case, the greater should be the

ductility of the joint. On the other hand, it seems probable that even the most skilful operators will be unable to hold quite so short an arc with the larger current.

29. Spot and Arc Welding

A good deal of progress is being made in America in the use of Spot Welding for the joining of thick plates. It is believed that Spot Welding has a great future as applied to shipbuilding and several large spot welders have been built for shipyards. In some of its applications, Spot Welding affords a method of preliminarily joining the hull plates, after which the required additional strength is provided by arc welding. The Welding Research Sub-Committee has already made some progress in comparing combined spot and arc welds and combined rivet and arc welds with riveted, spot-welded, and arc-welded joints. It is not a question in such an investigation of Spot *versus* Arc Welding, but of Spot *and* Arc Welding.

In the tests mentioned, the specimens were made up of the following combinations:

1. Spot and fillet welded (Fig. 9) (2 samples made).
2. Fillet Welded—made by welding fillets about 2 inches in length at the ends of the plates (Fig. 10) (2 samples made).
3. Riveted and filled welded (Fig. 11) (1 sample made).
4. Spot Welded—made by welding two spots approximately one inch in diameter, on the plates (Fig. 12) (2 samples made).
5. Riveted Joint, made by riveting a ½ inch × 4 inch × 12-inch plate with two plates ½ inch × 4 inch × 16 inch, using two ¾-inch rivets and a 4-inch lap. (One sample made.)

The results of the test show the comparative strength of the joints as follows:

Spot and Fillet Welded—	Ultimate	Load	*50,350 lb.
Fillet Welded—	"	"	*37,000 "
Riveted and Fllet Welded—	"	"	†35,000 "
Spot Welded—	"	"	*28,000 "
Riveted Joint—	"	"	†13,000 "

Spot welds, as compared with arc-welded butt joints, have the disadvantage of the increased weight corresponding to the overlap.

30. Condition of Surfaces to be Welded

While for Spot Welding the surfaces may sometimes be TOO clean to obtain the best weld, this cannot be the case with Fusion Welding. The

* Average of tests on two samples.

† Only one sample made.

question of the extent to which it is practicable to go in freeing the surfaces from impurities prior to making the Fusion Weld is entirely a commercial one. The cleaner the surface, the better the weld. In spot welding it is desirable to have clean surfaces under the electrodes, but scale between the two plates is a positive advantage.

31. Pre-heating and Heat Treatment and Hammering While Cooling

Pre-Heating, Heat Treatment and Hammering, as applied to Fusion Welding (both Gas and Electric) have been the subjects of research, but as yet nothing adequately comprehensive has been planned. It is very important that these deficiencies should be recognized and remedied.

32. Time Required to Train Welders

As to the training of welders, there are on the one hand those who are so ill-informed as to assert that good welding can be done after a very few weeks of training, while on the other hand, others assert that an operator can hardly acquire any considerable degree of skill in much less than a year. Still others advocate the substitution of automatic feeds and the complete elimination of dependence upon manual dexterity. For arc welding work requiring more than 100 amperes this is, in the Author's opinion, not a trade for women when the arc is manipulated by hand as distinguished from the use of automatic or semi-automatic machinery.

33. Question of Need for Special Machines for Welding

A great variety of machinery for supplying and controlling the current for welding is on the market. Some of this machinery comprises elaborate mechanisms in virtue of which it is claimed that it would be very difficult for even a novice to make a bad weld. Some advocate the use of simple resistance to be inserted in series with the arc on any available circuit, and claim that any additional machinery is superfluous. The capital outlay for the equipment of a welder (at the point of consumption) when the first kind of equipment is used, may be a matter of over $1000.00, while in the second case, well below half of the sum is sufficient.

34. Technique of Testing Welds

The ideal weld should presumably be at least as strong and as durable as the metal of the members joined together. In other words, the section containing the weld should have the same chemical and physical characteristics as adjacent sections in the original metal. A weld is therefore

measured by the degree of approximation to this condition as determined by mechanical, chemical and metallurgical tests of:

(a) The parent metal
(b) The welded joint
(c) The deposited material in the weld.

While during the last year the Welding Research Sub-Committee has made a great deal of progress in establishing standard procedures for the mechanical testing of welds, much still remains to be done. Obviously, the procedure for testing the original metal should follow standard practice as recommended by the American Society for Testing Materials, but there is considerable difference of opinion and uncertainty as just how and what mechanical tests should be made of the welded joint and of the deposited metal. For instance

(a) Should all the usual observations be taken when making a tensile test of a welded joint? Obviously the strength of the union between the two pieces of metal should be determined but in view of the non-homogeneity of the specimen, does not a very different significance attach to yield point, elongation and reduction of area? Where a series of welds having the same ratio of deposited material to original metal is concerned, such data are undoubtedly important for comparison purposes but for evaluating a weld in terms of the original metal, questions are repeatedly being raised as to just what extent these data have value.

(b) Would not more reliable information as to the ductility of the weld be obtained if elongation and reduction of area measurements were made on specimens prepared from the deposited metal or from specimens cut lengthwise of the weld instead of crosswise?

(c) Similarly with the bending test, which is a test for ductility. There are some (including the author) who would make the bend with the axis of the mandrel *normal* to the weld instead of parallel thereto, which latter position is the one usually employed. It may be that both tests should be made; the normal position as test of the ductility of the deposited material and the parallel position as an additional test of the union between the deposited material and the original metal.

(d) How important are torsion tests and impact or shock tests in measuring welded joints?

(e) Fatigue tests of welded joints are generally conceded to be vital and the importance of obtaining reliable information as to how this test should be made probably transcends (at present at least) that attached to any other research in the field of Fusion Welding. The researches should be made:

(1) With the Moore Bending Fatigue Machine

(2) With rod samples rotated at high speed as employed by Lloyd's Register in England

(3) With the Strohmenger Torsion-Fatigue Machine
(4) With the Cammell-Laird Bending Fatigue Apparatus
(5) By the Upton-Lewis Test.

After the necessary research work has been done to solve these and other similar questions pertaining to the testing of welds, standard specifications for the testing procedure can be prepared which will be properly balanced between the cost of making the tests and the amount of testing necessary to insure a reliable estimate of the weld.

Conclusion

The extent of the field of application for Fusion Welding and Spot Welding is but little appreciated by engineers other than those who have been directly connected with welding developments. It is evident that this field is an enormous one, including as it does all structures where steel is employed, such as bridges, building structures, tanks of all types and kinds, railway rolling stock, and ships, in addition to numberless miscellaneous applications in industry in general.

However, engineers associated with Welding Research should be on their guard that their enthusiasm over this great field of application shall not lead them into prematurely endorsing the use of Fusion Welding or Spot Welding in constructions where the consequences of failure involve serious menace to life and property, as may often be the case. For example, a particularly important case is that of pressure vessels and especially large high-pressure containers. The success in one hundred installations will not excuse failure (accompanied possibly by fatalities), in the one hundred and first installation. It is the opinion amongst the best informed engineers that before Fusion Welding can advisedly be employed for large high-pressure vessels, much vigorous and elaborate research work should be carried out on the fatigue characteristics of fusion welds of long seams, and that this research work must comprise full-sized structures since the conditions cannot be reproduced in test samples.

In fact, if the general acceptance of welding, particularly by Inspection Boards, Underwriters, and Classification Societies, is to be accomplished in a reasonably short time, such extensive Research Work on a large scale is absolutely essential in order to demonstrate conclusively that welded joints are equal to or better than joints made by other methods. Obviously the development of the art could proceed along the lines of the usual order of evolution as in the cases of previous arts, but this would, as in those cases, involve the lapse of years.

For structures subjected to less extreme stresses, such as the hulls of ships, the adequacy of Fusion Welding as a substitute for riveting is in

process of being thoroughly demonstrated in actual practice in Great Britain. It is recognized that the hulls of ocean-going ships are exposed to very great stresses, nevertheless there is a clear distinction between the magnitude of those stresses and the stresses to which many large, high-pressure containers are subjected.

The Author hopes this paper will aid in focusing attention on the vast importance of the welding art, particularly by occasioning discussion of the many problems in Welding Research, some of which have been mentioned in the paper.

The Author cannot undertake to give adequate acknowledgment of his indebtedness to his many associates in the preparation of this paper. The most generous assistance has been given him on every hand. Mr. William Spraragen has extended much assistance in preparing data and in many useful ways. Mr. F. M. Farmer, Chief Engineer of the Electrical Testing Laboratories, has given very generously of his time in advising the Author in detail about many points which arose in the course of the preparation of this paper.

Three Appendices accompany this paper:

Appendix A: Standard Procedure for Testing Welding Electrodes.

Appendix B: The Wirt-Jones Tests of Arc Welded Half-inch Ship Plates.

Appendix C: Bending Tests of Gas Welds.

APPENDIX A

STANDARD PROCEDURE FOR TESTING WELDING ELECTRODES. WELDING COMMITTEE, EMERGENCY FLEET CORPORATION NOVEMBER, 1918

1. *Purpose.*—The purpose of this specification is to provide a standard procedure for testing welding electrodes for electric arc welding which are submitted for the information of, and with the view to the approval by, the Welding Committee of the Emergency Fleet Corporation.

Note.—This specification describes a test of electrodes and not a combination of an electrode and of an apparatus. The fact that the applicant is given the option of selecting the system with which the test is made, does not make it a test of that system, any more than the employment of a particular welding operator could be said to make it a test of a welding operator. The system used in making these tests may or may not prove to be of importance. It is sought to minimize the influence of the individuality of the operator by requiring the test to include welds made by at least two operators.

The Welding Committee has two other Sub-Committees into whose province falls the Approving and Certifying of Operators and the Approving and Certifying of Systems. The admission that these three tasks overlap does not involve any reason for delaying the important task of proceeding at once with the standardizing of the testing of electrodes.

2. *General Conditions.*—(*a*) Each applicant shall provide at his factory or elsewhere as he may elect, the necessary facilities and at least two operators for making the test welds prescribed by these specifications. Except when otherwise indicated in these specifications, the applicant shall select the apparatus and other conditions for making test welds which he considers most suitable for his electrodes.

(*b*) The test welds shall be made in the presence of an *authorized representative* of the Welding Committee of the Emergency Fleet Corporation who will be empowered to certify as to the compliance with the conditions prescribed in the specifications. Also representatives of Lloyd's Register of Shipping and the American Bureau of Shipping shall have the opportunity to witness the making of the test welds.

(*c*) Until otherwise declared, the *authorized representative* of the Welding Committee shall be the Electrical Testing Laboratories, 80th Street and East End Avenue, New York, N. Y.

(*d*) The Welding Committee shall assume charge of the complete test welds and have them tested by the *authorized representative* in accordance with these specifications.

(*e*) The *authorized representative* shall render to the Welding Committee a complete, detailed report of each test of an electrode.

(*f*) The cost of carrying out the prescribed tests shall be borne by the applicant.

3. *Sample Electrodes.*—About 100 pounds of each electrode to be tested, which will be known as the *sample,* shall be furnished without charge. It shall be accompanied by an affidavit giving the following information:

(*a*) The *trade name* under which the electrode is marked together with certification that all electrodes bearing this trade name will be substantially the same as the sample submitted.

(*b*) The manufacturer of the complete electrode.

(*c*) The location of the factory in which the electrode was made.

(*d*) The manufacturer of the welding wire.

(*e*) The location of the mill in which the welding wire was produced.

(*f*) The chemical analysis of the welding wire.

The *authorized representative* shall retain the remainder of the sample for reference purposes.

4. *Plate Material.*—For these tests one-half inch ship plate shall be used. This material shall comply with the "*Standard Specifications or Structural Steel for Ships*" as adopted by the American Society for

Testing Materials, serial designation A 12-16 (see page 98, A. S. T. M. Standards, 1918).

An abstract of this specification is as follows:

1. Open hearth steel.
2. Phosphorous $\begin{cases}\text{acid steel, not over 0.06 per cent.}\\ \text{basic steel, not over 0.04 per cent.}\end{cases}$

   Sulphur, not over 0.05 per cent.
5. Tensile strength, pounds per square inch, 58000–68000.

   Yield point, minimum pounds per square inch, 0.5 tensile strength.

   Elongation in 8 inches, minimum per cent., $\frac{1,500,000}{\text{tensile strength}}$.
6. Yield point by drop of beam method.
7. Cold bend test; no cracking on outside of bent portion when bent 180 degrees around a pin the diameter of which is equal to the thickness of the plate.

5. *Cutting of Plates.*—(*a*) The method of cutting a plate 5 feet by 20 feet into pieces for welding is shown in the accompanying reproduction of drawing No. 102 of the Bureau of Standards.

(*b*) Each plate shall be given a distinguishing letter, A, B, etc. This letter shall appear upon each piece cut from it.

(*c*) Pieces shall be plainly marked with the letter and number arranged as shown in the drawing so that the location of the piece in the plate may be determined.

(*d*) The plates from which tensile, cold bend and fatigue specimens are to be made, shall be cut into pieces 9 inches by 30 inches (see Fig. 14).

(*e*) The plates from which impact specimens are to be made shall be cut into pieces 30 inches by 30 inches (see Fig. 17).

Notes.—A power shear may be employed for cutting these plates if they are left flat. Pieces whose dimensions are within ¼ inch of the required size will be satisfactory.

6. *Arrangement of Pieces for Welding.*—(*a*) All welds are to be made across the grain, that is the welded joint is to be at right angles to the direction of rolling. Fig. 15 shows the correct arrangement of the pieces for the test welds to be used for the physical tests, but in Fig. 17, which shows the arrangement of pieces for the impact test, pieces such as J–1 and J–2 should be taken for a test weld instead of J–1 and J–9.

(*b*) Preparatory to making a weld, one 30-inch edge of each piece will be beveled at the angle preferred by the applicant. If he has no preference, the angle of the bevel shall be 30 degrees as shown in Fig. 15. The bevel is not to be carried through to the bottom edge but only to within 1/16 inch of the bottom edge. In other words, the ends of the pieces to be welded are not to be beveled to a sharp point but 1/16 inch of the original square edge will be left at the bottom of the Vee.

(*c*) For welding, the pieces shall be placed horizontally with their under surfaces raised approximately ⅛ ineh above the supporting surface. The beveled edges shall be placed parallel and separated ⅛ inch.

(*d*) The weld shall in all cases be of the type known as a double bevel.

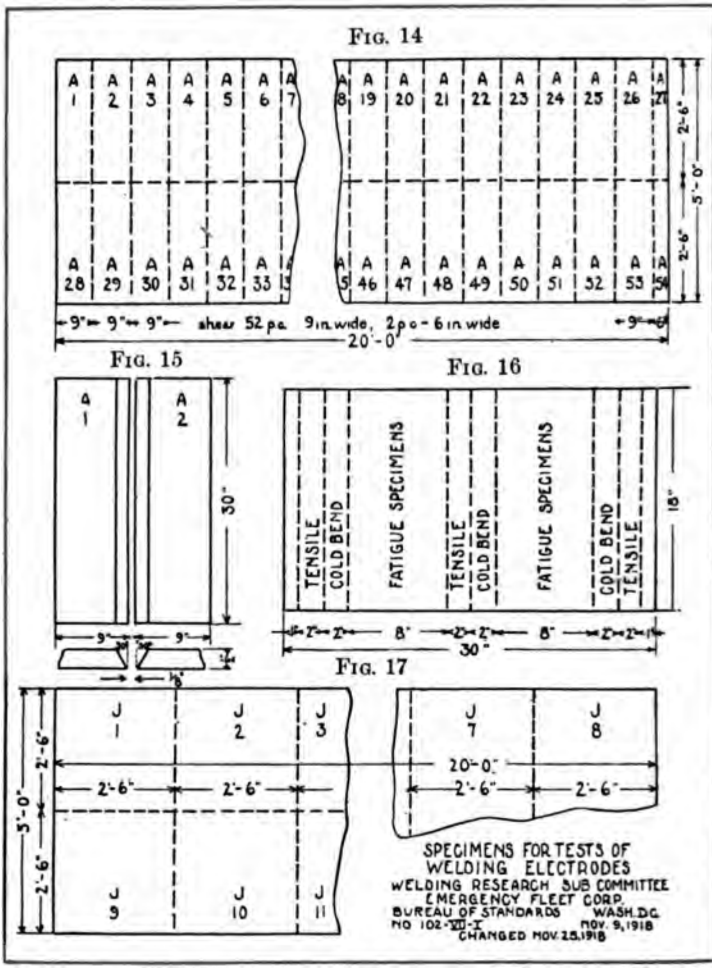

FIG. 14 FIG. 15 FIG. 16 FIG. 17

7. *Welding of Pieces.*—(*a*) The pieces, which shall be dry and free from rust and foreign substance, shall be "tacked" at each end and in the middle of the joint by welding the plates at each of these places for about one-half inch.

(*b*) After "tacking" the weld shall be completed by working continuously from one end of the joint to the other. The welding material shall be added in at least two layers and when completed the surface of the weld shall be at least flush with and not more than ⅛ inch above the

upper surface of the plate. The width of the weld at the top shall not be greater than 1¼ inches. All welding shall be done from the open side of the Vee.

(c) After each layer of a weld is completed, it shall be inspected by the *authorized representative*. If unsatisfactory, a new test weld shall be substituted and a report made of reasons for rejection.

8. *Number of Test Welds.*—(a) The welds will be made by three skilled operators, two of whom will be furnished by the applicant and one by the Welding Committee.

(b) Each operator shall make one 30-inch weld for the tensile, cold bend and fatigue tests (see Figure 15) using direct current and a similar weld using alternating current. For these tests, therefore, six (6) test welds will be required for each sample electrode.

(c) Each operator shall also make one 30-inch test weld for the impact test (see Fig. 17) using direct current and a similar weld using alternating current. For impact tests, therefore, six (6) test welds will be required for each sample electrode.

(d) If, however, the applicant intends his electrode for use with only one kind of current, that kind only shall be used in making the welds. In that case only three (3) test welds will be required for (b) and for (c) instead of six (6).

9. *Arrangement of Conductors.*—(a) One of the conductors shall be attached to a clamp which will be fastened to both pieces at the end of the joint opposite that from which work is started.

(b) For direct current work, the electrode shall have the polarity desired by the applicant. In the absence of any preference on his part, the instructions of the *authorized representative* shall be followed.

10. *Welding Data.*—The following information and observations shall be recorded by the *authorized representative* during the welding operations:

(a) Trade name or other identification mark of the electrodes.

(b) Complete description of the electrode.

(c) Sufficient description to identify the welding apparatus or system employed.

(d) Identification marks on the pieces consumed being welded.

(e) Name of operator.

(f) Kind of current (*i.e.*, dc. or ac.); if dc., polarity and if ac., frequency.

(g) Electrical quantities as follows: arc volts (both open and closed circuit), arc current and arc watts.

(h) Room temperature and humidity.

(i) The opinion of the *authorized representative* of the working quality of the electrode. This statement to include a description of any sputtering, boiling or other noticeable peculiarities.

(j) Elapsed time per weld.

(k) Weight of electrode consumed per weld.

(l) Any other information which will assist in determining the performance of the electrode, such as a photograph of at least one weld, etc.

11. *Preparation of Welded Plates and of Specimens for Physical Tests* (see Fig. 16).

(a) Each test weld shall be machined down on both sides to about the surface of the plate.

(b) Specimens shall be cut from *each* test weld reserved for physical tests as follows:

1. *Three Tensile Specimens.*—These shall be machined to a uniform width of 1.5 inches unless a weld of great strength makes it necessary to leave shoulders at the ends, in which case the standard A. S. T. M. test specimens for sheet iron and steel shall be prepared.

2. *Three Cold Bend Specimens.*—These shall be machined to a uniform width of 1.5 inches.

3. *Six Fatigue Specimens.*—These shall be machined to about ½ inch diameter and 10 inches long. (The exact dimensions are to be determined by experiment.)

12. *Physical Tests.* (a) *Tensile Strength.*—Each of the three specimens shall be tested in accordance with the practice recommended by the A. S. T. M. and shall include the determination of the tensile strength, yield point (by drop-of-beam method), reduction of area and total elongation after rupture in 2 inches and in 8 inches.

(b) *Cold-bend Test.*—This test shall be made by placing the specimen on two rollers with the apex of the Vee upward and midway between the rollers and loaded at the center of the span thus formed by a cylindrical surface having a diameter of ½ inch. This surface shall bend the specimen downward between the rollers until a fracture appears on the lower side of the specimen when loading shall be stopped and the angle noted through which the specimen has been bent.

(c) *Fatigue Test.*—Each of the six specimens shall be tested in a special rotating type of machine similar to that used by Lloyd's Register of shipping. (Exact details to be determined by experiment.)

(d) *Impact Test.*—Each impact-test specimen shall be placed on supports 18 inches high and 4½ feet apart. A spherical weight of 500 pounds shall be allowed to fall freely through a distance of 10 feet striking the weld which shall be at the center of the span. The apex of the Vee shall be upward.

(e) *Test of Original Plate.*—In order to establish the physical properties of the unwelded plate, tensile, cold-bend and fatigue tests shall be made on a sample selected at random from the pieces used for the test welds but before such welds are made.

Optional Tests

The following tests are optional with the applicant but the Welding Committee considers that they give information of great importance and recommends that they be made in order to make the report on the electrode more complete.

13. *Chemical Analysis.*—A chemical analysis shall be made of:

(*a*) The original plate in one test weld selected at random.

(*b*) The metal at the center of one test weld selected at random. If test welds are made with both dc. and ac., an analysis shall be made of one weld of each set.

14. *Photomicrographs.* — Photomicrographs shall be made of one specimen weld selected at random as follows: (If test welds are made with both dc. and ac., photomicrographs shall be made of one weld of each set.)

(*a*) At center of weld.

(*b*) At juncture of weld and original metal.

(*c*) In adjacent original metal.

(*d*) Cross section of electrode.

(*e*) Longitudinal section of electrode.

Appendix B

Wirt-Jones Tests of Arc-welded Half-inch Ship Plate

In Tables 4 and 5 are set forth the results of the tests carried out in 1918 on arc-welded half-inch ship plate by the Welding Research Sub-Committee. The plates with which the welds were made had their edges prepared with a 45-degree double-Vee. The welds were made by a dozen different concerns. In each instance the operator employed whatever conditions were considered most suitable. Several types and sizes of electrodes, including both bare and covered, were used. While in the majority of cases direct current was employed, alternating currents of 25 and 60 cycles are also represented in the series. The number of layers and the current employed and, indeed, all the conditions, were left to the discretion of the individual operator. The length of the weld was 8 in. After the welds were made, the plates were cut up by the Wirt Company (thanks to the courtesy of Mr. Charles Wirt). The tests were made at the Bureau of Standards under the direction of Prof. H. L. Whittemore. The tensile tests were made on specimens with a cross-section of 1 in. by ½ in. Specimens with the weld machined have the projecting metal planed off so that the welded portion is smooth and of approximately the same cross-section as the remainder of the

specimen. For the specimens with the weld not machined, no record was made of the added cross-section due to the projecting material.

The cold bend specimens were 1 in. by ½ in. and were bent around a mandrel of 1.5 in. diameter. The results of the tensile and bending tests for the machined samples are given in Table 4. Those for the samples which were not machined are given in Table 5.

TABLE 4.—*Wirt-Jones Tests of One-half-inch Arc-welded Ship Plates*
(Machined Samples)

Test Number	Current in Amperes		Diam. of Elec. in In.	Current Density, Amp. per Sq. In.	Tensile Tests		Bending	Electrode		
	A. C.	D. C.			Ult. Lb. per Sq. In.	Per Cent. Elon. in 2 In.	Angle at which Crack Starts, Degrees	Cov.	Bare	Make
20	175	...	0.125	14,227	62,700	9.0	34	C	..	E. A. C. & W. Co.
1	...	175	0.166	9,118	59,800	9.0	42	..	B	Roebling
22	160	...	0.125	13,008	50,000	6.0	78	C	..	E. A. C. & W. Co.
2	...	155	0.156	8,075	62,600	11.5	44	..	B	Roebling
19	150	...	0.125	12,195	62,800	12.0	32	C	..	Quasi
31	...	150	0.166	6,930	60,900	8.0	..	..	B	Roebling
29	...	150	0.156	7,815	56,400	6.5	..	..	B	W. W. & M. Co.
38	150	...	0.156	7,815	54,500	7.0	45	C	..	E. A. C. & W. Co.
29	...	150	0.156	7,815	54,400	6.0	47	..	B	W. W. & M. Co.
9	...	150	0.156	7,815	44,200	4.0	26	..	B	Toncan
9A	150	...	0.187	5,430	42,500	4.0	30	..	B	Armco
10	...	150	0.156	7,815	41,900	4.5	25	..	B	Toncan
10	...	150	0.156	7,815	41,300	4.5	24	..	B	Toncan
9	...	150	0.156	7,815	38,100	4.0	15	..	B	Toncan
9A	150	...	0.187	5,430	36,300	4.0	..	..	B	Armco
5	...	145	0.156	7,554	61,100	8.5	55	..	B	Am. S. & W. Co.
25	136	...	0.156	7,085	43,700	3.5	26	..	B	Roebling
30	...	135	0.156	7,033	53,200	11.0	..	..	B	W. W. & M. Co.
30	...	135	0.156	7,033	52,000	10.5	50	..	B	W. W. & M. Co.
37	125	...	0.125	10,162	56,400	7.0	42	C	..	E. A. C. & W. Co.
7	...	120	0.125	9,756	57,600	8.5	50	..	B	Roebling
7	...	120	0.125	9,756	53,700	7.0	45	..	B	Roebling
8	...	115	0.125	9,349	59,400	13.5	60	..	B	Roebling
8	...	115	0.125	9,349	58,200	14.0	..	..	B	Roebling
3	...	115	0.156	5,891	50,600	5.0	34	..	B	Am. S. & W. Co.
16	...	110	0.134	7,799	50,250	7.0	35	C	..	Quasi
27	...	110	0.125	8,943	45,800	8.0	42	..	B	Roebling
21	105	...	0.134	7,444	42,200	5.0	42	C	..	E. A. C. & W. Co
26	94	...	0.125	7,642	34,200	3.0	15	..	B	Roebling
18	90	...	0.134	6,381	54,000	6.0	65	C	..	Quasi
15	...	90	0.134	6,381	39,400	4.0	30	C	..	Quasi
24	...	86	0.125	7,154	45,400	6.0	15	..	B	Roebling
23	...	85	0.125	6,930	51,900	4.0	..	..	B	Roebling

TABLE 5.—*Wirt-Jones Tests of One-half-inch Arc-welded Ship Plates*
(Samples Not Machined)

Test Number	Current in Amperes		Diam. of Elec. in Inches	Current Density, Amp. per Sq. In.	Tensile Tests		Electrode		
	A. C.	D. C.			Ult. Lb. per Sq. In.	Per Cent. Elon. in 2 In.	Cov.	Bare	Make of Electrode
20	175	...	0.125	14,275	66,480	11.0	C	..	E. A. C. & W. Co.
22	160	...	0.125	13,008	66,400	9.0	C	..	E. A. C. & W. Co.
19	150	...	0.125	12,195	65,400	6.0	C	..	Quasi
5	...	145	0.156	7,554	52,280	7.0	..	B	Am. S. & W. Co.
25	136	...	0.156	7,085	47,800	4.0	..	B	Roebling
3	...	115	0.156	5,891	65,470	13.0	..	B	Am. S. & W. Co.
27	...	110	0.125	8,943	48,200	7.0	..	B	Roebling
16	...	90	0.134	6,381	58,740	5.2	C	..	Quasi
18	90	...	0.134	6,381	61,760	11.0	C	..	Quasi
15	...	90	0.134	6,381	57,340	8.0	C	..	Quasi
23	...	85	0.125	6,910	57,060	5.0	..	B	Roebling

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Mental Factors in Industrial Organization*

BY THOMAS T. READ, E. M., PH. D., NEW YORK, N. Y.

(New York Meeting, February, 1919)

READJUSTMENT of the industrial world to a peace basis after more than 4 years of war will involve many fundamental and far-reaching changes that cannot as yet be clearly foreseen or definitely provided for. Such problems may be subdivided, in the vocabulary of war, into those involving material and those centering about personnel. Of the two, the latter group is the more difficult and obscure, as the factors involved are less clearly understood and the methods to be followed are not yet tested and standardized. When it is said that the market is weak, stocks large, and demand light, every business man understands clearly what is meant and what course he should adopt to adjust himself, so far as possible, to such conditions. But when it is said that the rapid spread of Bolshevism in Europe is a danger to industrial organization in this country, it is difficult to have any assured sense that all that the statement may mean is clearly understood or that the means to be followed to meet such a situation are definitely known. Since Bolshevism is primarily a mental phenomenon and since the rupture it brings about in industrial organization should be prevented, if possible, it is my purpose to restrict this discussion of the activities of the Committee on Industrial Organization to some of its mental aspects, as the chairmen of the sub-committees, from their special knowledge of their own fields, can best set forth recent progress in the lines with which they are especially concerned.

The first requisites of success in industrial organization, as in the biological organism of which it is the social counterpart, are unity of purpose and coördinated activity. Typical good and bad examples of this are the relative parts that the United States and Russia have played in the great war. These two factors are primarily mental, and it is not difficult to view the mental aspects of all problems of industrial organization as the most important ones. Unless we can attain unity of purpose and coördinated activity in industry, the provision of comfortable homes at reasonable rent, the assurance of steady work at good wages, the

* Report of Chairman of Institute's Committee on Industrial Organization.

elimination of industrial accidents, and provision against want in old age or in case of disability will have brought us no nearer to our real goal.

An industrial organization is made up of three groups: those who furnish the capital and take the risk of the enterprise, but frequently have little active part in it after it is firmly established; those who represent the first class in the active direction of the enterprise; and those who give their energies for an assured wage, without assuming any of the risk. Some of the reasons why these three elements find it difficult to achieve unity of purpose and perfectly coördinated activity are indicated below, in the hope that their statement in this brief form will draw forth helpful discussion.

Activity of any kind, up to the fatigue point, is agreeable to any human being, if it has an adequate motive and offers an opportunity for self-expression. Under such circumstances much effort may be put forth and great discomforts endured with equanimity. A good example of this is duck-hunting; very few people care to spend more than a few days in this form of activity, for the motive declines in relative importance and the discomforts relatively increase. Under most forms of industrial organization, the workman has little motive for labor, beyond the wage offered; his opportunity for self-expression comes in the character of the work done. The growing complexity of industrial processes due to research, and the immigration into the eastern United States of large numbers of workmen of relatively low intelligence, has lead to the development of the functional, or so-called scientific, system of management. This method was developed by F. W. Taylor as the best way of supervision of men of inferior grades of intelligence. Its great drawback when applied to workmen of higher intelligence is that it almost completely robs them of the few opportunities for self-expression in their work that remain under the modern system of assigning only one operation out of many to an individual. The management still finds its motive and self-expression in putting on the market a product that can be sold at a good profit, but the workman is too remote from this to feel any satisfying part in it, although the industrial value of an established brand or trademark must not be overlooked, since the workman finds some satisfaction in laboring to turn out a product of recognized merit. Safety work has accomplished some good along this line by what is known in psychology as deflection; the workman does a standard amount of work without any accident and finds his opportunity for self-expression in the latter feature of it. Company baseball teams, bands, first-aid teams, and similar activities that enable the individual employee to express his personality are of value. But the net result of the present tendency in industry is for the workman to see in his work only the unpleasant necessity of earning a living and to find his mental satisfaction in other forms of activity. This is

putting the cart before the horse; it is just as though the army went to defeat the enemy only as an unpleasant necessity and found compensation for its sacrifices in something else. The various profit-sharing schemes that have been devised are only a makeshift and do not introduce the workman as a partner into the enterprise in the sense that his motive becomes identified with that of the organization. The fundamental fact remains that the workman is not in a position to take much risk, and how he can be made a partner in industrial enterprise without sharing its risk is an unsolved problem.

The wonderful possibilities of an adequate motive and properly coördinated activities has been indelibly impressed on every business man who visited the training camps of our National Army and saw the results accomplished in a few months' time with what must have been slightly below average human material, since many of the most effective men secured industrial exemption. No one who has seen it can forget the tense eagerness of both officers and men. An industrial organization that could inject anything like the same spirit into its personnel would be, like our army, invincible. Coördination of activity depends on leadership; identification of motive in industrial organization is impossible unless the principle is admitted that the opinions of the laboring members of the organization are entitled to a respectful hearing and consideration on their merits.

Underlying these general considerations are the mental characteristics of the individual workman. Perhaps the most significant of these for our present purposes is the necessity to the individual for rationalizing his acts, or the assigning to them of a motive that is satisfactory to himself. A man, for example, strikes another who has insulted him, not because he is angry, but because honor requires it; or he refrains from striking him, not because the other is too large to strike with impunity, but because it would be too undignified to do so. In this way the most unworthy acts can be put on high moral grounds. Sabotage is a typical example of this in industry. The mental reaction in a man who can make only a poor living by hard work and is confronted with the easy success of others more fortunate is too apt to be one of jealousy and the end product the adoption of a "what's the use of trying" attitude. We all talk of equality of opportunity and have too much tendency to overlook the fact that it is largely beyond the control of ourselves or anyone else. Two soldiers of equal merit may be assigned to the infantry. One gets into battle, captures an enemy gun, escapes unhurt, is decorated, returns in triumph, and is elected mayor of his home town. The other contracts pneumonia and dies in a field hospital. Up to the limit of human control both had equal opportunity. It is admitted that both were of equal merit, yet the reaction many of their colleagues will exhibit is sympathy in the one case and a feeling that "I could have done it better

if I had had the chance" in the other. When with this latter feeling is coupled a tendency to rationalize a wrong course of action, the individual becomes very badly adjusted to the circumstances under which he must live. A rough definition of a Bolshevik would be a person who is dissatisfied with things as they are and is able to rationalize a course of action that experience indicates will make them worse instead of better.

The next point to be here considered is that efficiency is in large part a question of mental adaptation. Dr. Yerkes is to present to our membership an account of the methods that have been developed under the auspices of the War Department to determine the relative intelligence of men as an indication of their fitness to become officers. The trade tests developed by the same committee are of even greater interest in industrial organization. Capital has become too cheap and human effort has become too dear to admit much longer of the time-honored method of trial and error as a means of fitting the job to the man. The man who is not fitted to his job is constantly having the ground cut from beneath his feet by discouragement and discontent, two arch enemies of efficiency. The greater part of progress along this line has yet to be achieved, for we have made only a beginning as yet.

There are many other normal mental factors that might profitably be discussed but they must be left for consideration at another time in order to pass on to the second half of this subject, the relation that mental abnormalities bear to industrial organization. It is now definitely known that some people exhibit throughout their lives mental abnormalities and others exhibit them at times. The paranoids form one group. If these are of the depressed type, they are surly and suspicious, believe themselves to be unjustly treated, and fail to appreciate any kindness shown them. The Kaiser has been described as an example of the exalted type, persons who believe they are benefiting others while making infinite trouble for them. Another definite group comprises the emotionally unstable, who show a tendency to brood and be unhappy, but are modest and self-effacing. They are always ready to undertake anything new, but tire of it before it is completed. They are marked by the violence of their reactions to slight provocation. It is definitely known that these types are present in industrial organization, but neither their numbers nor their effect on the normal psychology of the organization has yet been ascertained. In addition to these permanently abnormal people are those who are temporarily deranged. People who cannot stand worry, overwork, or other unfavorable conditions give way mentally and one-fifth of those admitted to insane asylums each year are of this type. Most of them later get well. There may be hundreds of thousands of cases of mental disturbance of this kind that do not reach the point of requiring admittance to the asylum, just as a man may have a severe cold but not go to the hospital. It seems reasonable to suppose that the

paranoids may have a large effect in breaking down unity of purpose and coördination of activity in a normal body of workmen and that the emotionally unstable may play a large part in inciting the violent outbreaks that sometimes attend industrial disputes. Since mental abnormalities of this kind are relatively more common among people of marked ability than among the mediocre, it is hardly necessary to add that mentally abnormal persons may be found in the management as well as in the working force. It is the hope of this committee that it will be able to do some pioneer work in ascertaining the prevalence of the mentally abnormal in industry, determine the actual effects, what means should be taken to minimize the bad effects and to utilize to the fullest possible extent whatever possibilities there may be for good.

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Investigations of Aerial Transport in Mining Districts in South America

BY GEORGE M. DYOTT, LONDON, ENG.

(New York Meeting, February, 1919)

SUMMARY OF PAPER

THERE are many who may consider a paper on aerial transport and its possibilities in connection with mining operations somewhat premature. Nevertheless, as there is considerable interest manifested in the subject at the present time and the amount of information available is both scanty and misleading, the result of investigations in some of the remote mining districts of Peru will not only be of interest, but will help crystallize, in the minds of many, a more correct conception of just what an airplane is capable of doing.

By way of introduction, I will deal briefly with the types and varieties of airplanes now in use, and the developments of the past few years, pointing out how the war has encouraged machines of startling performance rather than those of commercial utility. I will then take up aerial transport in general, showing how airplanes may be employed to advantage and the particular kind of work for which they are best suited. This will cover a preliminary discussion on cost, which is one of the most important phases of the subject. In passing on from a general survey of the situation, I will deal with actual observations and investigations made in Peru. This part of the paper will be divided into two sections: the first, covering the mountainous districts of the Andes (Tamboras, Pataz, Soledad, etc.); the second, the alluvial deposits in the rivers, Chinchipe, Santiago, and Napo. In each case the question of atmospheric conditions, altitude, landing grounds, motors, cost, etc. will be discussed. While it is my intention to deal chiefly with mining in the sections mentioned, the same line of argument will be applicable to any other districts in the world. In conclusion, I will touch on the possibilities of using lighter-than-air craft of the Zeppelin type, followed by a summary of the most salient points brought out in the paper.

In a general way the points emphasized will be:

1. That freight can be carried by means of airplanes.

2. That certain kinds of freight are more suitable for aerial transport than others.

3. That aerial transport will not compete with existing methods of transport, but will extend their sphere of usefulness.

4. That airplanes will prove a valuable adjunct to many mining operations.

5. That certain mines, which it is now impossible to open, can be put on sound lines of development by the intelligent use of air craft.

6. That many gold-dredging operations can benefit by the employment of flying boats or hydro-airplanes

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A Study of Shoveling as Applied to Mining

BY G. TOWNSEND HARLEY,* TYRONE, N. M.

(New York Meeting, February, 1919)

Summary and Conclusions†

Shoveling ore cost so much at Tyrone during the year 1917 that it was deemed advisable to conduct tests to see where the fault lay. These tests were in the nature of time studies and extended over a period of very nearly a year. No data were available on this work to supply a starting point, so it was necessary to begin in a very elementary way, to find out the capacity of the average Mexican laborer.

To obtain a basis for comparison, it was necessary to determine the capacity of various types and sizes of shovels, so as to know whether the 21-lb. (9.5-kg.) load was the best load underground as well as on surface. A list of essential factors influencing shoveling was also made out during the course of a short series of preliminary time studies, and the motions involved in shoveling were analyzed and subdivided for convenience in studying. The necessary forms and record sheets were also decided upon at this time. A second short series of tests was then conducted on the surface, so as to be able to estimate the negative effects of underground work on the shovelers, and to minimize, as far as possible, the need for studying obviously poor types and sizes of shovels under the difficult conditions to be encountered in the mine.

The test work underground consumed by far the greater proportion of the time and was divided into three series: Shoveling directly into a chute; shoveling into a wheelbarrow and tramming to a chute; and shoveling into a car and tramming to a chute. In each series the following points were determined for various lengths of time worked: Number of shovelfuls handled per minute, effect of distance thrown on shoveling speed, amount of rest required, amount of time consumed in tramming and dumping, proportion of working day occupied in shoveling, total tonnage handled during various working periods, effect of distance on tonnage handled during the day.

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* Efficiency Engineer, Phelps-Dodge Corp., Burro Mountain Branch.

† This paper, which contains 36 illustrations, 17 of them being charts of especial value, and 4 tables, has been printed in pamphlet form. Copies of it will be sent free of charge to all persons interested; they will also be distributed at the meeting.

These tests showed that the design of the shovel has a very marked effect on the shoveling efficiency and that with the proper weight and size of tool the man's efficiency will be increased in spite of himself. It was demonstrated that a man handling a total load of 26 lb. 8 oz. (12 kg.) did the greatest day's work, other things being equal, and that this load is divided into a live load of 21 lb. (9.5 kg.) and a shovel weight of 5 lb. 8 oz. (2.5 kg.). A shovel weighing 5 lb. 8 oz. made out of the best composition steel gives very excellent service, and a lower cost per ton than a shovel having a lower first cost.

Further marked increases in shoveling efficiency are to be gained by instructing the shovelers in the proper methods of using a shovel, a thing that very few laborers know in spite of the fact that they may have been shoveling for a living for years.

Probably the most important part of all efficiency work lies in the wage that is paid to the men, the manner of paying the wage, and the feeling of confidence and good will that exist between the men and the company. Various types of wage payment are briefly discussed and the conclusion is reached that the bonus system in some form, if properly handled and carefully watched with a sufficient number of specially trained men to instruct the laborers and keep them working to the best advantage, is the preferable system of payment. A bonus schedule is proposed as a starting point for the work and the benefits that will probably be derived from it are outlined, using some actual stoping experience as an example.

Scientific management systems applied to certain eastern factories have demonstrated conclusively that the efficiency of the average workman can be increased by from 50 to 250 per cent. and that at the same time the men will receive better wages, will remain in better health, and will be happy and contented, while the company will actually produce its products at a lower cost.

F. W. Taylor, working at the Bethlehem Steel Co. plant several years ago, increased the capacity of the iron-ore shovelers from 16 T. to 59 T. per day per man, raised the men's wages from $1.15 to $1.88 a day, and at the same time decreased the operating cost from $0.072 to $0.033 per ton shoveled. The increase in shoveling capacity amounted to 269 per cent. Figures obtained at Tyrone indicate that the tonnage in at least one of the large stopes can be raised from 8.5 T. per man to 22.9 T. per man, an increase of 169 per cent., the wages can be raised from $3.40 a day to $4 a day, and the cost to the company reduced from $0.33 a ton to $0.24 a ton, after taking care of all extra supervision needed. In addition to this actual saving in shoveling costs, the overhead and general mining costs will be reduced per ton by mining a greater tonnage per man; and the other classes of labor such as machine miners and tim-

ber men will be able to do more work, as they will not be hampered and delayed by the shovelers to such an extent as at present.

Labor should not be given too much of an increase in wages over what is recognized as a fair living wage, as the men will at once tend to become shiftless and prosperity does them more harm than good.

The modern manager is beginning to see that the relation of standard times to the other features of organization is very close and vital. The determination of the standard, or the shortest time, in which a job can be done, is the starting point for all work that has as its aim the establishing of an equitable wage system.

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Effect of Temperature, Deformation, and Grain Size on the Mechanical Properties of Metals*

BY ZAY JEFFRIES,† MET. E., D. SC., CLEVELAND, O.

(New York Meeting, February, 1919)

SUMMARY‡

A MORE complete interpretation of the amorphous theory in metals is given than has heretofore been offered. It is believed that Le Chatelier, Tammann, and Heyn, at present the ablest opponents of the amorphous theory, will not be able longer to continue their beliefs that surface tension alone can account for all the observed variations in the properties of single constituent metals.

It is strongly advocated that the properties of any solid substance be studied from the standpoint of the number of constituents present, the quantity and arrangement of each constituent, and the properties of each constituent. Each deformable crystalline constituent by plastic deformation will produce amorphous material, thus changing the properties.

Considerable attention is given to the variations in properties of the amorphous and crystalline phases of any substance. These are summarized as follows:

1. The cohesion of the amorphous phase of a substance is substantially zero at the melting point while the cohesion of the crystalline phase is considerable at the melting point. With decrease in temperature, the cohesion of the amorphous phase increases at a faster rate than that of the crystalline phase; this differential rate of change of cohesion holds between absolute zero and the melting point. At a certain temperature

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* Part 2 of thesis submitted to Harvard University for degree of Doctor of Science, May 1, 1918. Part 1 appeared in *Jnl.* Inst. Metals (No. 2, 1918).

† Director of Research, Aluminum Castings Co.

‡ This excellent paper, which contains 38 micrographs, 32 diagrams, and 25 tables, has been printed in full for distribution at the meeting. Copies of it will be sent, free of charge, to all persons who are interested.

for each substance, the cohesion-temperature curves of the amorphous and crystalline phases intersect. In most ductile metals, this intersection occurs at about 0.35 to 0.45 of the absolute melting point. This point of intersection has been called the "equi-cohesive" temperature; below it the amorphous phase is not only more cohesive than the crystalline but it increases in cohesion with decrease in temperature at a faster rate than the crystalline phase. Above the equi-cohesive temperature, the amorphous phase is not only weaker than the crystalline phase but its cohesion decreases with increase in temperature at a faster rate. The equi-cohesive temperature corresponds closely to the lowest recrystallization temperature of a metal after severe cold work. Recrystallization seems to be caused by grain growth and grain growth does not seem to take place until a temperature is reached at which the amorphous phase is softer than the crystalline. These facts, coupled with a knowledge of the arrangements and relative quantities of the amorphous and crystalline phase, enable one to account for the observed mechanical properties of a metal.

2. The coefficient of expansion of the amorphous and crystalline phases of a substance, in general, should vary inversely as their cohesion. The rate of change of expansion with change in temperature should be great in the amorphous phase and small in the crystalline phase. There should be a temperature of equal expansion but this may not correspond to the temperature of equal cohesion. The same analogy may be considered for the modulus of elasticity and other related properties, such as compressibility.

The difference in coefficient of expansion between the amorphous and crystalline phases may cause intercrystalline brittleness in a metal at low temperatures. The temperature at which a metal becomes brittle on cooling can be made lower by changing the arrangement of the amorphous phase into a less commanding position. For example, equiaxed tungsten becomes brittle between 100° and 200° C. on cooling. By changing the equiaxed to a fibrous structure, the metal retains useful ductility at and somewhat below room temperature.

3. If a non-allotropic metal is worked below its recrystallization temperature, its elongation and tenacity increase below the temperature at which it was deformed and decrease above it up to the recrystallization temperature.

4. The rate of deformation of the amorphous phase with a given absolute cohesion is much less than that of the crystalline phase at a temperature of equal cohesion. At the equi-cohesive temperature, for example, the amorphous phase deforms slowly under a given load while the crystalline phase deforms quickly. The measured equi-cohesive temperature will be higher, therefore, the shorter the time of test. This causes the strength, elongation, and reduction of area of metals tested

above their recrystallization temperatures to increase. The amorphous phase may remain within its elastic limit with a short duration of a given load and deform with long duration; the permanent bending of glass rods and tubes after resting months or years in bent positions would be due to this factor. The same pieces of glass could be bent at room temperature and would come back to their original positions if they were held in their bent positions a short time only. The lag in expansion and contraction of such hard amorphous materials as fused silica is no doubt caused by this same phenomenon.

5. This idea that the amorphous phase deforms at a slower rate than the crystalline is not consistent with the idea that the amorphous phase itself passes through a mobile state during deformation. It is more probable that the mobile state occurs while the amorphous phase is in the process of formation at the slip planes; the mobile state is the one permitting a slip and this generates amorphous material. In overcoming the momentum of the slip, the atoms of the amorphous phase are probably left in a state of strain immediately after deformation. The slow adjustment of the strained amorphous metal should account for the observed changes in properties with age, in such metals as iron. The same reasoning holds for the amorphous phase at grain boundaries. Adjustment of atoms and removal of strain take place after an annealed metal is cooled; in hard metals this change will be slow and in soft metals rapid.

6. The mechanical properties of iron can be explained best by assuming that an allotropic change occurs between room temperature and 450° C. All the tensile properties of both annealed and cold-worked iron show discontinuities in this temperature range. Annealed iron is 20 to 25 per cent. stronger between 200° and 300° C. than at room temperature. This increase in strength can be imparted to the metal at room temperature by working in the region of the stronger allotrope. It is assumed that allotropy is associated with the crystalline phase only, that is, it is caused by a change in the arrangement of the atoms. If allotropy proves to be due to a change within the atom, these views can be easily adjusted to the new idea.

7. The mechanism of rupture is discussed. If a crystal breaks without deformation, it is probable that no amorphous material is generated at the planes of fracture. The ability of a crystal to be deformed depends absolutely on its ability to generate amorphous metal at points of incipient rupture. Rupture takes place by degrees, that is, all parts of the fracture do not separate at the same time; ductility favors rupture by degrees. The reduction of area at the point of fracture is a result of rupture by degrees. Rupture by degrees also favors a low breaking load but at the same time it tends to make a long path of rupture. The balance of these two tendencies will control the breaking load and reduction of area and hence the elongation. The amorphous phase has the ability

to flow like glass at relatively high temperatures but, like glass, it is rigid and brittle at low temperature.

8. The results of several hundred tensile tests on copper, tungsten and iron at temperatures between −190° and 900° to 1000° C. are discussed. The results are summarized in the graphs shown in Figs. 43 to 73 inclusive.

9. A brief note is given dealing with the interpretation of the properties of complex alloys. A suggestion as to the method of attack on the solid-solution mystery is given.

Natural gas to the value of $120,000,000 was marketed in the United States in 1916, for nearly two and one-half times the value of all the silver produced in this country that year.

The establishment of an export coal association under the Webb-Pomerene law, open to all bituminous coal exporters in the United States has been recommended in a report by the Foreign Trade Committee of the National Coal Association.

Gold production in the United States in 1918 fell to 3,313,000 fine oz., worth $68,493,000, the lowest in 20 years, and silver production dropped to 67,879,000 fine oz., worth $67,879,000 at the standard Government price of $1 an ounce, the smallest record since 1913.

INDUSTRIAL SECTION

This department is devoted to material concerning the products or operations of manufacturers, which, in the estimation of the Editor, is of news value to the mining and metallurgical field but does not come within the scope of the main editorial section of the Bulletin.

Manufacturers are invited to submit to the Editor items descriptive of new equipment or processes, large or significant installations, and similar material of news character. If found available, items thus furnished will be published in this section without charge, subject to such editorial revision and condensation as may be necessary.

In cases where illustrations are required, cuts of the proper size should accompany the text matter.

JEFFREY STANDARD ELEVATORS

Years of experience in the building of conveying and elevating equipments of all kinds have made it possible for The Jeffrey Mfg. Co. to select and standardize forty elevators, which are now known as the Jeffrey Standard Elevators, are made vertical or upon an incline and can be furnished with or without steel casings. Their capacities range from 6½ to 80 T. per hr. with vertical lifts of from 10 to 75 ft. They consist of endless chains provided with buckets, of steel or malleable iron, spaced at short equal intervals apart or close together.

The nature of the materials handled may vary from non- or semi-gritty materials, such as grains, coal, and similar materials, to gritty substances, such as ashes, coke, sand, gravel and stone. The size of material may vary from dust to 4½-in. cubes. They are designated as coal, ashes, and stone elevators, simply because these materials are typical of the class of materials for which the different types are adapted. Likewise, coal, ashes, and stone, weighing approximately 50, 40, and 100 lb. per cu. ft., offer a convenient basis on which to figure the capacity of an elevator when handling material of some other weight.

In the selection of an elevator for handling lumpy material the size of the buckets is determined by the size of the pieces to be handled rather than by the capacity. Often the amount of material to be elevated may be small but the size of the pieces might be so large as to require a large size bucket irrespective of the capacity. If the material to be handled is heavier than that for which the elevator is designed, some provision should be made to insure that no more material enters the elevator boot or loading leg than the elevator is listed to handle, otherwise the elevator will be overloaded.

The coal elevators are furnished with or without steel casings but the ashes elevators are always furnished with steel casings unless otherwise ordered. They are also furnished with a 3-in. mesh grating to prevent large clinkers from entering into the boot and the discharge spout is lined with heavy renewable lining plates. The stone elevators are furnished in two distinct types: the centrifugal discharge type with buckets at intervals and the continuous bucket type where there is no space between the buckets. Continuous bucket elevators are not furnished with cast-iron boots but are provided with footshaft and takeup bearings and a steel loading leg for loading the material directly into the buckets. Casings are not ordinarily furnished with stone elevators of either type as this class of elevators is generally used for rough outside work where a steel casing is not desired. The centrifugal stone elevators may be vertical or inclined. The machinery

parts of both are identical except that the inclined elevators are furnished with simply a footshaft and takeups instead of a cast iron boot and are intended to meet the requirements where it is desired to build a concrete or wood boot, or the nature of the material is such as to form its own boot. The inclined centrifugal and continuous types of elevators may be installed vertically if desired, in which case it is not necessary to use idlers to support the carrying strand.

AMSCO MANGANESE-STEEL SAND AND GRAVEL PUMPS

The centrifugal sand and gravel pump is generally recognized as the most economical means for handling sand, gravel, clay, silt, mine chats, sewage and all other detached solids. The first centrifugal pumps were intended for pumping clear water only, but it was soon found that they could be constructed so as to handle a percentage of solids. The mechanical and structural details of these pumps have been constantly improved until the modern pump is very economical and highly efficient. It was found that as an improvement in design enabled the pumps to handle more material, the wearing parts were subjected to a more severe service so that a harder and tougher metal was required. This problem has been solved by the use of manganese steel and the peculiar properties of this metal have added an element of safety as well as longer wear to the pumps. Sand and gravel, while passing through the pump at high velocity, are thoroughly scoured. Silt, clay, and earth are disintegrated and carried off suspended in the water at the discharge of pump or discharge line. The abrasive character of sand and gravel reduces the life of pump shells, runners, and other parts of the pump. Manganese-steel pumps possess the wear-resisting qualities demanded by the severe conditions encountered in sand and gravel pumping.

PERSONAL

W. H. K. Bennett has been appointed manager of the pump department of the American Manganese Steel Co.

TRADE CATALOGS

(Under this heading will be listed such catalogs or other advertising literature as may be received during the preceding month. Contributors should address their material to Engineering Societies' Library, 29 West 39th St., New York.)

FLANNERY BOLT Co. Pittsburgh, Pa.
Staybolt. Vol. 6, No. 4. Dec., 1918. Tate Flexible Staybolt.

LINK-BELT Co. Philadelphia, Pa.
Link-Belt Equipment for the Handling and Preparation of Coal at Mine. Book No. 333.

THE JEFFREY MANUFACTURING Co. Columbus, Ohio.
The Jeffrey Carrier. (Advance Bulletin to Catalog No. 210.) Bulletin No. 237.

STEERE ENGINEERING Co. Detroit, Mich.
Bulletin No. 35. Tar Cameras for Colorimetric Tar Determination.

THE OSTER MANUFACTURING Co. Cleveland, Ohio.
Oster Threading Tools. Lists 30 and 31. May, 1918.

U. S. METAL CAP AND STEEL Co. New York.
The Upressit Cap.

THE MINING AND METALLURGICAL INDEX

December, 1918

The Engineering Societies Library is prepared to supply the original, or a copy, translation, or abstract of any paper mentioned in the following index, at the following rates:

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In the following Index, volume numbers are given in heavy-faced figures, page numbers in light-faced figures. Approximate number of words is stated.

MINERAL RESOURCES

(Except Petroleum and Gas. See also Mining Geology and Mining Practice.)

ALSACE-Lorraine and German industry. *Engng.* (Nov. 15, 1918) **106**, 561–2. 800 w.

ARBOUIN copper mines at Cardross. L. C. Ball, Queensland Geol. Sur. *Pub. No.* 261, 1–70.

ARSENIC and its occurrences in South Queensland. H. I. Jensen, *Queensland Govt. Min. Jnl.* (Oct. 15, 1918) **19**, 455–8. 3500 w. Serial; (Nov. 15, 1918) **19**, 503–8. 4600 w. Conclusion.

ASBESTOS, British Empire's resources. *South Afr. Min. Jnl.* (Oct. 12, 1918) **28**, 100–1. 1300 w. From *Times Tr. Sup.*

BOVEY Tracey lignite deposits. A. Strahan, *Coll. Guard.* (Nov. 22, 1918) **116**, 1080–1. 1400 w. From Special Report on the Mineral Resources of Great Britain, v. 7, Part 1.

BRIEY and Longwy redeemed. Briey et Longwy délivrés. *Echo d Mines* (Dec. 1, 1918) No. 2602, 610–2. 1500 w.

BRITAIN'S mineral resources. *Coll. Guard.* (Nov. 22, 1918) **116**, 1087–8. 1500 w. From report prepared by Sir Lionel Phillips.

BRITISH Guiana. *Min. Jnl.* (Nov. 30, 1918) **123**, 686–7. 1000 w.

BRITISH iron ore resources. H. Louis, *Nature* (Nov. 28, 1918) **102**, 244–5. 1200 w.

CANNEL coal deposits, British. A. Strahan, *Coll. Guard.* (Nov. 29, 1918) **116**, 1131–2. 2900 w.

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CHROME and manganese ore producers. F. F. Sharpless, *Engng. & Min. Jnl.* (Dec. 14, 1918) **106**, 1039. 700 w. Letter.

CHROME near Contact, Montana. *Engng. & Min. Jnl.* (Dec. 21, 1918) **106**, 1083. 300 w.

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COAL and iron deposits, Manchuria. *Iron & Coal Tr. Rev.* (Nov. 15, 1918) **97**, 552–3. 1800 w. From paper by C. F. Wang, A. I. M. E. *Bull.* 134.

COAL and ore resources of Ukraine and railroad connections. F. Thiefs, Die Kohlen und Erzvorkommen der Ukraine und ihre Eisenbahnverbindungen. *Annalen für Gewerbe und Bauwesen* (May 1, 1918) **82**, 94–5. 2000 w.

COAL measures at Oxley Creek, Hughenden District. J. H. Reid, Geol. Sur. of Queensland *Pub. No.* 258, 1–16.

COAL mines of Semales. Les houillères de Semales. *Bull.* Tech. Suisse Rom. (Nov. 30, 1918) **44**, 217–8. 1000 w.

COAL mining in Queensland during 1917. *Coll. Guard.* (Nov. 29, 1918) **116**, 1137. 900 w. From a report by V. Jackson.

COAL resources of the Americas. B. L. Miller, *Bull.* Pan. Am. Union (Oct., 1918) **47**, 511–33. 22 p.

COAL resources of the Western front. H. H. Stoek, *Black Diamond* (Dec. 28, 1918) **61**, 576–8. 2100 w. Serial.

COKING coal, in Scotland, Occurrence of. Discussion of Mr. R. W. Dron's paper on. *Trans.* Inst. Min. Engrs. (Nov., 1918) **56**, 28–9. 800 w.

COPPER deposits, Indian river, Vancouver mining division. C. Camsell, Can. Dept. of Mines. Geol. Sur. No. 1719, 23B–5. 1200 w.

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FLUORSPAR market and the local supply. A. L. Sweetser, *Engng. & Min. Jnl.* (Dec. 14 1918) **106**, 1031–2. 1200 w.

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FRANCE'S iron and steel industry. *Engng. & Min. Jnl.* (Nov. 30, 1918) **106,** 966. 700 w.

GERMAN iron and manganese supplies after the war. P. Krusch, Storleken av Tysklands järnmalmslager och dess försörjning med. järn och manganmalm efter kriget. *Jern-Kont Ann.* (Oct. 15, 1918) **19,** 515–31. 16 p.

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GOLD, Maximum production of, a world necessity. J. Clausen, *Min. Cong. Jnl.* (Dec., 1918) **4,** 468. 600 w.

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GOLD, Restrictions in use of, and gold mining situation. *Metal Rec.* (Oct., 1918) **4,** 323. 500 w.

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POTASH, Our natural resources. F. W. Brown, *Min. & Sci. Pr.* (Dec. 7, 1918) **117,** 759–62. 3500 w.

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POTASH resources of United States. J. M. Matthews, *Min. Jnl.* (Dec. 7, 1918) **123,** 708. 600 w.

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RADIUM: Its properties and occurrence in nature. R. B. Moore, *Metal Rec.* (Nov., 1918) **4,** 348–51. 4400 w. Serial. From A. I. M. E. *Bull.* 140.

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(See also Mineral Resources)

ACETYLENE and electric cap lamps from a safety standpoint. H. M. Chance, *Coal Age* (Dec. 19, 1918) **14,** 1118–21. 3400 w. Paper read before National Safety Council, Sept., 1918.

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AUSTRALASIAN Institute of Mining Engineers, Visit to Newcastle. C. T. Stephenson, *Indust. Austral.* (Oct. 3, 1918) **60,** 493–6. 5400 w.

"BOUNCE," An unusual, condition. A. C. Watts, *Coal Age* (Dec. 5, 1918) **14,** 1028–30. 1500 w.

BRITISH Guiana. *Min. Jnl.* (Nov. 30, 1918) **123,** 686–7. 1000 w.

CAISSON method for foundations and mine shafts. G. R. Johnson, *Proc. Engrs. Soc. Westn. Pa.* (Oct., 1918) **34,** 489–518. 29 p.

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COAL mining in India in 1917. *Coll. Guard.* (Nov. 22, 1918) **116**, 1079–80. 1500 w. From report of G. F. Adams, Chief Inspector of mines in India.

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COAL mining, Training of students in. F. W. Hardwick, *Coll. Guard.* (Dec. 6, 1918) **116**, 1187–8. 1500 w. From a paper read before the Midland Inst., Dec. 5, 1918. *Iron & Coal Tr. Rev.* (Dec. 6, 1918) **97**, 638. 1500 w.

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COPPER enterprise, Utah. T. A. Rickard, *Min. & Sci. Pr.* VI. (Nov. 30, 1918) **117**, 713–24. 5500 w. Serial.

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DEVELOPMENT period of a mine. H. H. Stoek, *Coal Age* (Dec. 12, 1918) **14**, 1076–7. 1700 w.

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DUST abatement in mines. W. O. Borcherdt, *Engng. & Min. Jnl.* (Dec. 21, 1918) **106**, 1084–5. 1100 w. Letter.

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ELECTRICITY in mining. L. Folkes, *Sci. & Art of Min.* (Nov. 16, 1918) **29**, 120–1. 900 w; (Nov. 30, 1918) **29**, 134–5. 1300 w.; (Dec. 14, 1918) **29**, 150–1. 1400 w.

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GERMAN machine for tunneling. F. Schmitt. Machine allemande pour le creusement des tunnels et des galeries de mines. *Génie Civil* (Nov., 1918) **73**, 421–3. 1500 w.

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HAZARD coal field. P. M. Sherwin, *Coal Age* (Dec. 5, 1918) **14**, 1031–4. 1400 w.

HOISTING ropes. M. M. Sigafoos, *Mech. Wld.* (Nov. 1, 1918) **64**, 208–9. 1500 w. Abs. of paper read before National Safety Council.

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LAS VACAS gold mine, Chile, D. Pope, *Engng. & Min. Jnl.* (Nov. 30, 1918) **106**, 958–60. 2300 w.

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MINE locomotives, Chair for. R. S. Morgan, U. S. Pat. 1284130. *Off. Gaz.* (Nov. 5, 1918) **256**, 184. 100 w.

MINE motor, New type. D. I. Wheeler, *Coal Age* (Dec. 26, 1918) **14**, 1167. 400 w.

MINE rescue apparatus, Self-contained. *Nature* (Nov. 14, 1918) **102**, 205–9. 2600 w. First report of the Mine Rescue Research Committee.

MINE shaft, Safeguarding the. D. E. Charlton, *Engng. & Min. Jnl.* (Dec. 21, 1918) **106**, 1061–3. 1500 w.

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COAL-handling plant at Sewalls Point, Virginia. *Coal Age* (Dec. 19, 1918) **14**, 1122–4. 1100 w.

COAL-handling plant of Virginian Railway. E. F. Case, *Ry. Rev.* (Nov. 23, 1918) **63**, 731–5. 2100 w.

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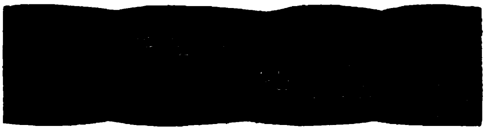

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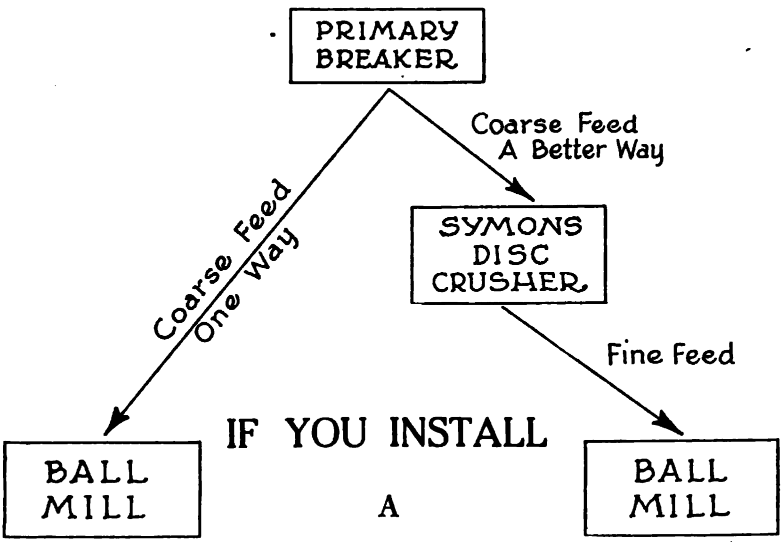

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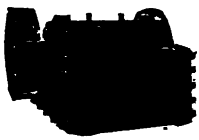

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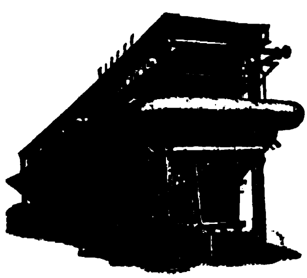

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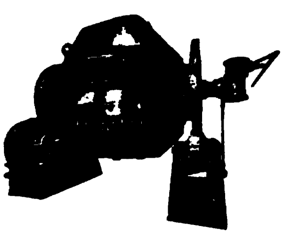

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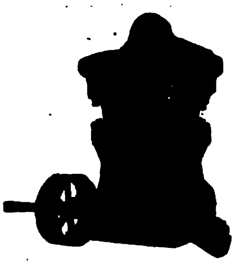

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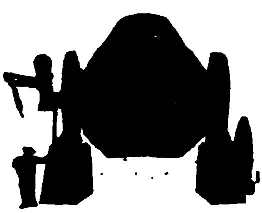

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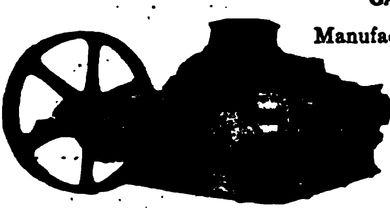

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Engines, Oil
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Engines, Steam
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Explosives
Du Pont de Nemours & Co., E. I., Wilmington, Del.

Fans, Ventilating
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Feeders, Ore
Buchanan Co., C. G., 90 West St., New York City.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Robins Conveying Belt Co., Park Row Bldg., New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Ferro-Chrome
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Ferro-Manganese
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Ferro-Molybdenum
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.
Primos Chemical Co., Primos, Pa.

CLASSIFIED LIST OF MINING AND METALLURGICAL EQUIPMENT

Ferro-Silicon
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Ferro-Tungsten
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.
Primos Chemical Co., Primos, Pa.

Ferro-Vanadium
Primos Chemical Co., Primos, Pa.

Filtering Paper
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Filters
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Fire Clay
Harbison-Walker Refractories Co., Farmers' Bank Bldg., Pittsburgh, Pa.
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Flotation, Oil
Colorado Iron Works Co., Denver, Colo.

Flue Welding Machines
Macleod Co., Bogen St., Cincinnati, Ohio.

Fluorescent Calcium Tungstate
Primos Chemical Co., Primos, Pa.

Fluorspar (Domestic and Foreign)
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Forges, Oil and Rivet
Macleod Co., Bogen St., Cincinnati, Ohio.

Forgings, Heavy
Holmes & Bros., Inc., Robt., 30 N. Hasel St., Danville, Ill.

Fuller Mill Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Furnaces, Assay
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.
Macleod Co., Bogen St., Cincinnati, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.

Furnaces, Electric
General Electric Co., Schenectady, N. Y.
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Furnaces, Flue Welding
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Gas
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Lead
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Mechanical Roasting
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Wedge Mechanical Furnace Co., Greenwich Point, Philadelphia, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Furnaces, Muffle
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Oil
Macleod Co., Bogen St., Cincinnati, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.

Furnaces, Reverberatory
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Smelting
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Furnaces, Tire Heating
Macleod Co., Bogen St., Cincinnati, Ohio.

Gears
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Generators, Acetylene Welding and Cutting
Macleod Co., Bogen St., Cincinnati, Ohio.

Generators, Electric
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Grinders, Sample
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Grizzly & Riffle Bars (For Hydraulic Mines)
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Guns, Cement
Macleod Co., Bogen St., Cincinnati, Ohio.

Guns, Concrete
Macleod Co., Bogen St., Cincinnati, Ohio.

Gyratory Crusher Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Hangers, Mine
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Hitchings Mine Car
Macomber & Whyte Rope Co., Kenosha, Wis.

Hoists, Electric
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Flory Mfg. Co., S., Bangor, Pa.
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Hoists, Skip
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Hoists, Steam
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Flory Mfg. Co., S., Bangor, Pa.
Holmes & Bros., Inc., Robt., 30 N. Hasel St., Danville, Ill.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Hoppers, Weigh
Holmes & Bros., Inc., Robt., 30 N. Hasel St., Danville, Ill.

Hose, Air
Denver Rock Drill Mfg. Co., Denver, Colo.
Goodrich Rubber Co., B. F., Akron, O.

Hydrated Ferric Oxide (For Gas Purification)
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Hydraulic Mining Machinery
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Insulators, Third Rail
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Jackets, Water
Traylor Engineering & Mfg. Co., Allentown, Pa.

Jaw Crusher Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Jigs
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Colorado Iron Works Co., Denver, Colo.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

CLASSIFIED LIST OF MINING AND METALLURGICAL EQUIPMENT

Laboratory Supplies
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Lamps, Acetylene
Macleod Co., Bogen St., Cincinnati, Ohio.

Lamps, Electric
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Lead Acetate
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Linings, Ball and Tube
Traylor Engineering & Mfg. Co., Allentown, Pa.

Linings, Brake
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Litharge
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Loaders, End
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.

Loading Booms
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Locomotives, Compressed Air
General Electric Co., Schenectady, N. Y.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Locomotives, Electric Trolley
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Locomotives, Gasoline
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Locomotives, Steam
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Locomotives, Storage Battery
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Low Carbon Ferro-Manganese
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnesia Brick
Harbison-Walker Refractories Co., Farmers' Bank Bldg., Pittsburgh, Pa.
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnesite Cement
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnesium Metal (Ingots and Powder.)
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnetic Pulleys (See Pulleys, Magnetic)

Manganese Dioxide (Lump and Ground)
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Manganese Ore
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Meters, Electric
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Mica
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Mills, Ball, Tube and Pebble
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Chalmers & Williams, Inc., 1465 Arnold St., Chicago Heights, Ill.
Colorado Iron Works Co., Denver, Colo.
Fuller-Lehigh Co., Fullerton, Pa.
Hardinge Conical Mill Co., 120 Broadway, New York City.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n, 115 Broadway, New York City.

Mills, Chilean
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Mills, Stamp
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n, 115 Broadway, New York City.

Mine Car Hitchings (See Hitchings, Mine Car)

Mining Machinery
Chalmers & Williams, Inc., 1465 Arnold St., Chicago Heights, Ill.

Molybdate of Ammonia
Primos Chemical Co., Primos, Pa.

Molybdate of Calcium
Primos Chemical Co., Primos, Pa.

Molybdate of Soda
Primos Chemical Co., Primos, Pa.

Molybdenum Metal
Primos Chemical Co., Primos, Pa.

Molybdenum Ore, Buyers of
Primos Chemical Co., Primos, Pa.

Molybdic Acid
Primos Chemical Co., Primos, Pa.

Motors, Electric
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Muffles
Mine and Smelter Supply Co., 42 Broadway, New York City.

Ore-Bedding Systems
Robins Conveying Belt Co., Park Row Bldg., New York City.

Ore Handling Machinery
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Robins Conveying Belt Co., Park Row Bldg., New York City.

Ore Milling Machinery
Colorado Iron Works Co., Denver, Colo.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Worthington Pump & Machinery Corp'n, 115 Broadway, New York City.

Ores, Buyers and Sellers of
Vogelstein & Co., Inc., L., 42 Broadway, New York City.

Oxy-Acetylene Apparatus
Macleod Co., Bogen St., Cincinnati, Ohio.

Packings, Steam
Johns-Manville Co., H. W., 296 Madison Ave., New York City.
Goodrich Rubber Co., B. F., Akron, O.

CLASSIFIED LIST OF MINING AND METALLURGICAL EQUIPMENT

Painting Machines
Macleod Co., Bogen St., Cincinnati, Ohio.

Pipe Insulations
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Plate Metal Work
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.

Platinum Wire, Foil & Ware
Heil Chemical Co., Henry, 210-214 S. 4th St. St. Louis, Mo.

Powder, Blasting
Du Pont de Nemours & Co., E. I., Wilmington, Del.

Powdered Coal Equipment
Fuller-Lehigh Co., Fullerton, Pa.
Ruggles-Coles Engineering Co., 50 Church St., New York City.

Power Transmission Machinery
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Presses, Filter
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pulleys, Magnetic
Buchanan Co., C. G., 90 West St., New York City.

Pulverizer Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Pulverizers
Hardinge Conical Mill Co., 120 Broadway, New York City.
Heil Chemical Co., Henry, 210-214 S. 4th St., St. Louis, Mo.

Pulverizers, Coal and Coke
Fuller-Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Pulverizers, Ore
Fuller-Lehigh Co., Fullerton, Pa.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Acid
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Centrifugal
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Hydraulic Pressure
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Pneumatic Air Lift
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Pumps, Power
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Sand
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Pumps, Sinking
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Stuff
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pumps, Track
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Pyrometers
Heil Chemical Co., Henry, 210-214 S. 4th St., St. Louis, Mo.

Quarrying Machinery
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Refractories
Harbison-Walker Refractories Co., Farmers' Bank Bldg., Pittsburgh, Pa.

Respirators
Goodrich Rubber Co., B. F., Akron, O.
Heil Chemical Co., Henry, 210-214 S. 4th St. St. Louis, Mo.

Revolving Screen Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Rock Drill Steel (See Steel, Drill)

Rods, Drill
International High Speed Steel Co., 99 Nassau St., New York, N. Y.

Roller Mill Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Rolls, Crushing
Buchanan Co., C. G., 90 West St., New York City.
Chalmers & Williams, Inc., 1465 Arnold St., Chicago Heights, Ill.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Roofings, Asbestos and Rubber-type
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Rope, Wire
Leschen & Sons Rope Co., A., 920 N. 1st St., St. Louis, Mo.
Macomber & Whyte Rope Co., Kenosha, Wis.
Roebling's Sons Co., John A., Trenton, N. J.

Rope Fastenings, Wire
Macomber & Whyte Rope Co., Kenosha, Wis.
Roebling's Sons Co., John A., Trenton, N. J.

Rubber Goods, Mechanical
Goodrich Rubber Co., B. F., Akron, O.

Samplers, Ore
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Scorifiers
Heil Chemical Co., Henry, 210-214 S. 4th St., St. Louis, Mo.

Screens, Bar
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.

Screens, Perforated Metal
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Screens, Revolving
Buchanan Co., C. G., 90 West St., New York City.
Chalmers & Williams, Inc., 1465 Arnold St., Chicago Heights, Ill.
Colorado Iron Works Co., Denver, Colo.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Robins Conveying Belt Co., Park Row Bldg., New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

CLASSIFIED LIST OF MINING AND METALLURGICAL EQUIPMENT

Screens, Shaking
Chalmers & Williams. Inc., 1465 Arnold St., Chicago Heights, Ill.
Holmes & Bros., Inc., Robt., 30 N. Hasel St., Danville, Ill.

Separators, Magnetic
Buchanan Co., C. G., 90 West St., New York City.

Shaft Sinking and Development Work
Longyear Co., E. J., 710 Security Bldg., Minneapolis, Minn.

Sharpeners, Drill
Denver Rock Drill Mfg. Co., Denver, Colo.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Silica Brick
Harbison-Walker Refractories Co., Farmers' Bank Bldg., Pittsburgh, Pa.

Skip Hoists (See Hoists, Skip)
Macomber & Whyte Rope Co., Kenosha, Wis.
Roebling's Sons Co., John A., Trenton, N. J.

Smelters
Vogelstein & Co., Inc., L., 42 Broadway, New York City.

Smelting Machinery
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Soda Ash
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Spelter
Illinois Zinc Co., Peru, Ill.

Spiegeleisen
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Sprockets
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Stamp Mill Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Steel, Drill, Hollow and Solid
Denver Rock Drill Mfg. Co., Denver, Colo.
International High Speed Steel Co., 99 Nassau St., New York, N. Y.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Steel, Tool
International High Speed Steel Co., 99 Nassau St., New York, N. Y.

Stokers
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Switchboards
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Tables, Concentrating (See Concentrators)

Test Lead
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Thawers, Switch
Macleod Co., Bogen St., Cincinnati, Ohio.

Thermometers
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Thickeners, Slime
Colorado Iron Works Co., Denver, Colo.
Dorr Co., Denver, Colo.

Tipple Machinery Equipment
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Torches, Cutting and Welding
Macleod Co., Bogen St., Cincinnati, Ohio.

Towers and Bridges, Stocking and Reclaiming
Robins Conveying Belt Co., Park Row Bldg., New York City.

Tramways, Wire Rope, Aerial
Leschen & Sons Rope Co., A., 920 N. 1st St., St. Louis, Mo.
Macomber & Whyte Rope Co., Kenosha, Wis.
Roebling's Sons Co., John A., Trenton, N. J.

Transformers, Electric
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Traps, Steam
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Tungstate of Ammonia
Primos Chemical Co., Primos, Pa.

Tungstate of Soda
Primos Chemical Co., Primos, Pa.

Tungsten Metal
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.
Primos Chemical Co., Primos, Pa.

Tungsten Ore
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Tungsten Ore, Buyers of
Primos Chemical Co., Primos, Pa.

Tungstic Acid
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.
Primos Chemical Co., Primos, Pa.

Turbines, Hydraulic
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Turbines, Steam
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Valves, Pump
Goodrich Rubber Co., B. F., Akron, O.

Vanadate of Ammonia
Primos Chemical Co., Primos, Pa.

Vanadic Acid
Primos Chemical Co., Primos, Pa.

Vanadium Chloride
Primos Chemical Co., Primos, Pa.

Vanadium Ore, Buyers of
Primos Chemical Co., Primos, Pa.

Ventilating Fans (See Fans, Ventilating)

Wagon Loaders
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Weigh Hoppers (See Hoppers, Weigh)

Wheels
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Wheels, Mine Car
Fuller-Lehigh Co., Fullerton, Pa.

Wire, Iron, Steel and Copper
Roebling's Sons Co., John A., Trenton, N. J.

Wire Mechanism (Lever Control)
Gwilliam Co., 253 W. 58th St., New York City.

Wire Rope (See Rope, Wire)

Wires and Cables, Electrical
General Electric Co., Schenectady, N. Y.
Goodrich Rubber Co., B. F., Akron, O.
Roebling's Sons Co., John A., Trenton, N. J.

Zinc Dust
Vogelstein & Co., Inc., L., 42 Broadway, New York City.

Zinc Sheet
Illinois Zinc Co., Peru, Ill.

ALPHABETICAL LIST OF ADVERTISERS

(With Summary of Products)

See pages 34–40 for Classified List of Mining and Metallurgical Equipment

* Advertisement does not appear in this issue, but products are listed in Classified List of Mining and Metallurgical Equipment.

 Please mention this BULLETIN when writing advertisers.

ALPHABETICAL LIST OF ADVERTISERS (Continued)

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Jeffrey Mfg. Co., 902 N. Fourth St., Columbus, O. 13
PRODUCTS: Electric Coal Cutters and Drills; Electric and Storage Battery Locomotives; Coal Tipple Machinery including Elevators, Conveyors, Picking Tables and Loading Booms, Car Hauls, Car Dumps, Screens, Crushers, Pulverizers, Fans, Hoists, etc.

Johns-Manville Co., H. W., New York City 31
PRODUCTS: Asbestos and Rubber-type Roofings, Roof Coating, Steam Packings, Pipe Insulations, Cements, Brake Lining and Brake Blocks, Steam Traps, Third Rail Insulators, Mine Hangers, Moulded Mica Weatherproof Sockets, Electrical Tapes and Fuses.

Lavino & Co., E. J., Bullitt Bldg., Philadelphia, Pa. .... *
PRODUCTS: Ores: Manganese, Chrome, Iron, etc. Ferro Alloys and Metals. Pig Iron.

Leschen & Sons Rope Co., A., St. Louis, Mo .... *
PRODUCTS: Wire Rope for all purposes, including Hercules Red Strand Wire Rope, and Wire Ropes of Patent Flattened Strand and Locked Coil constructions. Aerial Wire Rope Tramways for economical transportation of material.

Longyear Co., E. J., 710 Security Bldg., Minneapolis, Minn .... *
PRODUCTS: Contract Diamond Drilling, Manufacture of Diamond Drills and Supplies, Shaft Sinking and Development Work, Geological Department.

Macleod Co., Bogen St., Cincinnati, Ohio .... *
PRODUCTS: Oxy-Acetylene Cutting & Welding Apparatus for mine repair work, also portable oil burners for same purpose, metallurgical furnaces, carbide lights, and sand blast outfits.

Macomber & Whyte Rope Co., Kenosha, Wis 17
PRODUCTS: Monarch Whyte Strand Wire Rope, Patent Kilindo Non-Rotating Wire Rope. Wire Rope of all Grades and Constructions. Patent Monarch Mine Car Hitchings.

Mine & Smelter Supply Co., 42 Broadway, New York City 21
PRODUCTS: Manufacturers of Mining, Milling, Smelting and Crushing Machinery.

Primos Chemical Co., Primos, Pa. .... *
PRODUCTS: Molybdenum, Tungsten and Vanadium Products. Buyers of Molybdenum, Tungsten and Vanadium Ores.

Robins Conveying Belt Co., Park Row Bldg., New York City .... *
PRODUCTS: Belt Conveyors, Bucket Elevators, Ore Bedding Systems, Unloading, Stocking and Reclaiming Towers and Bridges, Conveyor Auxiliaries.

Roebling's Sons Co., John A., Trenton, N. J. .... *
PRODUCTS: Wire Rope for Mining Work. Stock shipments from agencies and branches throughout the country.

Roessler & Hasslacher Chemical Co., 100 William St., New York 29
PRODUCTS: Cyanide of Sodium and Other Chemicals for Mining Purposes.

Ruggles-Coles Engineering Co., 50 Church Street, New York ... Inside Back Cover
PRODUCTS: Manufacturers of the Ruggles-Coles Dryer for All Materials. Powdered Coal Equipment.

Sullivan Machinery Co., 122 S. Michigan Ave., Chicago, Ill. .... *
PRODUCTS: Coal Pick Machines, Air Compressors, Diamond Core Drills, Rock Drills, Hammer Drills, Mine Hoists, Chain Cutter, Bar Machines, Fans.

Traylor Engineering & Mfg. Co., Allentown, Pa. 23
PRODUCTS: Manufacturers of Mining, Milling, Smelting and Crushing Machinery.

Vogelstein & Co., Inc., L., 42 Broadway, New York .... *
PRODUCTS: Buyers, Smelters and Refiners of Ores and Metals of all classes.

Vulcan Iron Works, Wilkes-Barre, Pa. 5
PRODUCTS: Vulcan Electric Mine Hoists, Steam Hoists, Hoisting and Haulage Engines, Mining Machinery, etc. Nicholson Device for Prevention of Overwinding.

Wedge Mechanical Furnace Co., Greenwich Point, Philadelphia, Pa. .... *
PRODUCTS: The Wedge Mechanical Roasting Furnace (Patented).

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. .... *
PRODUCTS: The Baldwin-Westinghouse Electric Mine Locomotives. Electrical Machinery: Turbines, Generators, Motors, etc.

Wood Equipment Co., McCormick Bldg., Chicago, Ill. .... *
PRODUCTS: The Pneumatic Rotary Dump (Wood and Ramsay Patents). Adaptable to all mining conditions—old or new operations.

Worthington Pump and Machinery Corp'n, 115 Broadway, New York 25
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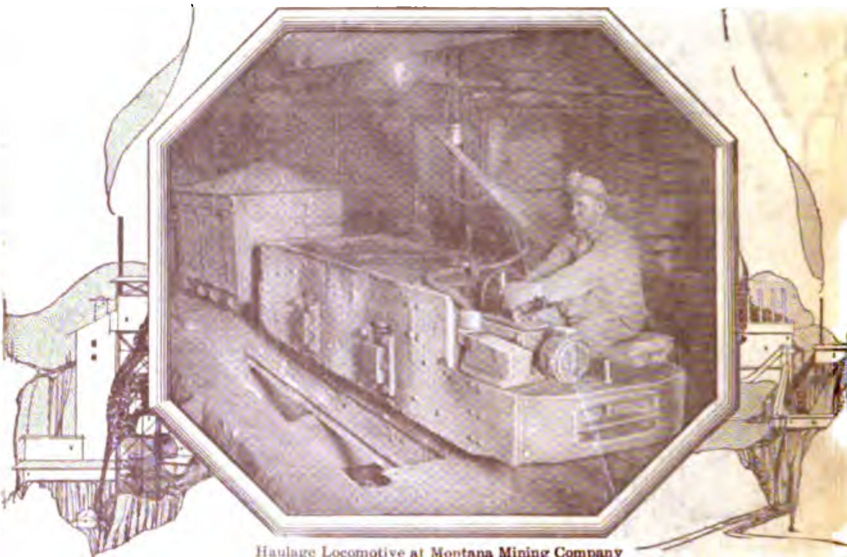

No. 147 March 1919

Bulletin of the American Institute of Mining Engineers

with which is consolidated the American Institute of Metals

SPECIAL FEATURES

PUBLISHED MONTHLY

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BULLETIN OF THE AMERICAN INSTITUTE OF MINING ENGINEERS

WITH WHICH IS CONSOLIDATED THE

AMERICAN INSTITUTE OF METALS

No. 147 MARCH 1919

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PROCEEDINGS OF THE 119TH MEETING

From the beginning to the end, the attendance and enthusiasm of the 119th meeting, which was held in New York, Feb. 17 to 20, surpassed all expectations. Besides the ten technical sessions, one of which was in conjunction with the American Institute of Electrical Engineering and one a session of the National Research Council, there were two memorial meetings, one for Dr. Raymond and one for the members who died in service; two joint sessions with the Canadian Mining Institute; and a meeting devoted to pictures of copper mining, milling, and smelting. Of the 732 persons registered, 119 registered in the Institute of Metals Division.

Monday's sessions were devoted to the problems of industrial organization, the Institute of Metals Division, and to petroleum and gas. Among the special features of these sessions were the topical discussions on housing and Americanization. Americanization, too, was the topic for discussion by the Woman's Auxiliary Wednesday morning.

On Tuesday, nearly 100 members of the Canadian Mining Institute were present to discuss the possibility of bringing about uniform mining laws for the United States, Canada, and Mexico, to obviate the maintaining separate legal departments and managerial forces for the several countries; and to avoid the confusion which, it is said, has led to a duplication of effort and has sometimes created a barrier to international coöperation in mining. Among the Canadian delegation were D. B.

Dowling, President of the Canadian Institute; John McLeish, Statistician in the Department of Mines; O. S. Finnie, Mining Engineer in the Department of the Interior; H. H. Rowatt, Controller in the Department of the Interior: and Colonel Machin, of the Department of Justice.

Wednesday was devoted to the work of the National Research Council, which occupied the entire day and not only the morning as was planned; to the problems of mining, milling, and geology; and to the study of welding problems, together with the American Institute of Electrical Engineers. In all cases the discussion was most animated.

The committees in charge of the arrangements were as follows:

Committee on Arrangements and Reception.—ALLEN H. ROGERS, Chairman; WALTER S. DICKSON, Secretary; S. H. BALL, G. D. BARRON, H. W. HARDINGE, P. W. HENRY, MRS. SIDNEY J. JENNINGS, J. E. JOHNSON, JR., A. C. LUDLUM, E. P. MATHEWSON, P. A. MOSMAN, H. C. PARMELEE, F. T. RUBIDGE, FOREST RUTHERFORD.

Finance Committee.—GEORGE D. BARRON, Chairman; J. PARKE CHANNING, WALTER DOUGLAS, JAMES GAYLEY, J. H. JANEWAY, C. F. KELLEY, W. H. NICHOLS, JR., W. W. MEIN, WILLIAM L. SAUNDERS.

Excursion Committee.—P. W. HENRY, Chairman; J. E. JOHNSON, JR.

Banquet Committee.—A. C. LUDLUM, Chairman; F. T. RUBIDGE, E. B. STURGIS.

Luncheon Committee.—P. A. MOSMAN, Chairman; E. MALTBY SHIPP, C. A. BOHN.

Automobile Committee.—H. W. HARDINGE, Chairman.

Entertainment Committee.—E. P. MATHEWSON, Chairman; LAWRENCE ADDICKS, LUCIUS W. MAYER.

Tellers.—*For Officers.*—W. S. DICKSON, H. N. SPICER, WILLIAM YOUNG WESTERVELT. *For Proposed Amendment.*—C. Q. PAYNE, R. C. WARRINER, A. D. BEERS.

NEWLY ELECTED OFFICERS OF THE INSTITUTE

The following officers were elected: Horace V. Winchell, of Minneapolis, President; Vice-presidents: Edwin Ludlow, Lansford, Pa.; A. R. Ledoux, New York; Directors: J. V. W. Reynders, New York; George D. Barron, Rye, N. Y.; Charles F. Rand, New York; Louis S. Cates, Ray, Ariz.; Stanley A. Easton, Kellogg, Idaho.

CHANGE IN NAME OF THE INSTITUTE

By a letter ballot of the members of the Institute, as reported by the tellers and announced by the President at the annual business meeting of the Institute on February 18, 1919, the name of the American Institute of Mining Engineers has been changed to the American Institute of Mining and Metallurgical Engineers. The vote for the amendment to the Constitution making this change was a heavy one for such matters, showing the very wide and deep interest taken by the members in this vital change. The actual count was 1274 for and 672 against.

It is the consensus of opinion that this marks an epoch in the history and usefulness of this Institute, and it is expected that the change will presage a large and healthy growth in metallurgical fields. Many metallurgists who knew nothing about mining were loath to join a society of mining engineers, despite the fact that over 35 per cent. of the papers published in our Transactions during the past five years have dealt with metallurgical subjects.

The choice of the name to be balloted for had been made by popular canvass and has the double advantage, much to be desired, of retaining the word Engineers and maintaining the former initials of the Institute, A. I. M. E. This change will doubtless make the Institute *the* metallurgical society of the country as it has been *the* mining society.

CANADIAN MINING INSTITUTE DAY

Four joint discussions formed the program of the sessions with the Canadian Mining Institute on Tuesday. T. W. Gibson, the representative of the Canadian Mining Institute, opened the discussion on the subject of "Principles of Mine Taxation" the American Institute was represented by Ralph Arnold, of the United States Treasury Department. Later, Alfred G. Heggem, of Tulsa, Okla., cited an instance in which a high rate of taxations decreased the Government's revenue by retarding the transfer of property. The second discussion in the morning was on the subject "Industry Democracy, and Education." C. V. Corless, represented the visitors and President Jennings the Americans. During the latter part of this discussion, D. B. Dowling, President of the Canadian Mining Institute presided.

In the afternoon, Mr. T. A. Rickard, of San Francisco, Cal., opened the discussion by a paper entitled "The English-speaking People." He was followed by Dr. A. R. Ledoux, of New York, who gave a brief talk on "International Coöperation." In it he spoke of the necessity of closer coöperation, also, with Mexico. President Jennings later said that he is planning a trip to Mexico, when he expects to meet with the Local Section in Mexico, at which time he hopes to initiate some discussion of problems that confront the American engineer. The question of a uniform mining law for North America provoked considerable discussion. While most of the talk was confined to the various Canadian laws, the possibilities of uniform laws with Mexico and Central America were also considered.

TECHNICAL SESSIONS

Institute of Metals Division

One session of the Institute of Metals Division was held on Monday morning, Feb. 17, Mr. W. M. Corse presiding. The following papers were presented:

Effect of Temperature, Deformation and Grain Size on the Mechanical Properties of Metals. By Zay Jeffries. (Presented by the author; discussed by C. H. Mathewson, P. D. Merica, S. L. Hoyt, and the author.)

Volatilization of Cuprous Chloride on Melting Copper Containing Chlorine. By S. Skowronski and K. W. McComas. (Presented by Mr. Skowronski.)

Automatic Copper Plating. By J. W. Richards. (Presented by the author; discussed by A. Silverman.)

Two Instances of Mobility of Gold in the Solid State. By E. Keller. (Presented by title.)

First Year of Leaching by the New Cornelia Copper Co. By H. A. Tobelmann and J. A. Potter. (Presented by title; written discussion by C. A. Rose.)

Die Castings and Their Application to the War Program. By Charles Pack. (Presented by title; written discussion by Jesse L. Jones.)

Electric Furnace Problems. By J. L. McK. Yardley. (Presented by title.)

The second session was held on Monday afternoon, Feb. 17, Mr. William B. Price presiding. The following papers were presented:

Comparison of Grain-size Measurements and Brinell Hardness of Cartridge Brass. By W. H. Bassett and C. H. Davis. (Presented by Mr. Bassett; written discussions by W. R. Hibbard, Arthur Phillips, C. H. Mathewson, W. H. White, W. B. Price.)

Manganese Bronze. By P. E. McKinney. (Presented by the author; discussed by E. P. Ross, G. H. Clamer; written discussions by Jesse L. Jones, W. M. Corse.)

Metals and Alloys from a Colloid-chemical Viewpoint. By Jerome Alexander. (Presented by the author; written discussion by W. D. Bancroft.)

Standards for Brass and Bronze Foundries and Metal-finishing Processes. By Lillian Erskine. (Presented by W. M. Corse.)

Industrial Organization

A session on Industrial Organization was held on Monday morning, Feb. 17, Mr. B. F. Tillson presiding, at which the following papers were presented:

Employment of Mine Labor. By H. M. Wilson. (Presented by the author; discussed by C. W. Goodale, M. D. Cooper, B. F. Tillson, E. A. Holbrook; written discussions by W. D. Brennan, W. L. Clark, and R. R. Goodrich.)

Use of Cripples in Industry. By J. P. Munroe. (Presented by the author.)

Mental Factors in Industrial Organization. By T. T. Read. (Presented by the author.)

Prevention of Illness Among Employees in Mines. By A. J. Lanza. (Presented by the author; discussed by C. W. Goodale, B. F. Tillson, H. M. Wilson, and the author; written discussions by C. E. Calvert and J. J. Carrigan.)

A second session on Industrial Organization was held on Monday afternoon, Feb. 17, with Mr. T. T. Read in the chair. The following papers were presented:

Mental Tests in Industry. (Presented by Robert M. Yerkes; discussed by Major Yerkes, Bradley Stoughton, B. F. Tillson.)

Need for Vocational Schools in Mining Communities. By J. C. Wright. (Presented by the author; discussed by Marguerite Jordan.)

Professional Lecture—U. S. Employment Service. By I. W. Litchfield.

Topical Discussion on Housing. The speakers were D. Eppelsheimer and Laurence Veiller.

Topical Discussion on Americanization. The speakers were A. J. Beatty and W. C. Smith.

Petroleum and Gas

On Monday afternoon, Feb. 17, there was a session on Petroleum and Gas. Capt. A. F. Lucas presided, and the following papers were presented:

Water Troubles in the Mid-continent Oil Fields, and Their Remedies. By Dorsey Hager and G. W. McPherson. (Presented by title.)

Natural-gas Storage. By L. S. Panyity. (Presented by the author.)

Economic and Geologic Conditions Pertaining to the Occurrence of Oil in the North Argentine-Bolivian Field of South America. By S. C. Herold. (Presented by the author.)

Petroleum Hydrology Applied to Mid-Continent Field. By R. O. Neal. (Presented by title; written discussion by G. Sherburne Rogers.)

Cement Plugging for Exclusion of Bottom Water in the Augusta Field, Kansas. By H. R. Shidel. (Presented by title.)

Session with Canadian Mining Institute

On Tuesday, Feb. 18, known as Canadian Mining Institute Day, three discussions took place, as follows:

PRINCIPLES OF MINE TAXATION. President Sidney J. Jennings, A. I. M. E., presided. Mr. T. W. Gibson, Canadian Mining Institute, opened the discussion, and was followed by Mr. Ralph Arnold and Mr. A. G. Heggem, A. I. M. E.

INDUSTRY, DEMOCRACY AND EDUCATION. President D. B. Dowling, Canadian Mining Institute, presided. Mr. C. V. Corless, Canadian Mining Institute, presented the paper on this subject. Mr. S. J. Jennings, A. I. M. E., made a short address.

INTERNATIONAL COÖPERATION IN MINING IN NORTH AMERICA AND UNIFORM MINING LAW FOR NORTH AMERICA. President S. J. Jennings, A. I. M. E., presided. The speakers were: For the Canadian Mining Institute, Mr. T. E. Godson, Mr. H. H. Rowatt, Mr. T. W. Gibson, Mr. T. C. Denis, Mr. A. R. Chambers; for the A. I. M. E., Mr. T. A. Rickard, Dr. A. R. Ledoux, Mr. H. V. Winchell.

Iron and Steel

There were two sessions on Iron and Steel on Tuesday, Feb. 18. At the first session, Dr. J. W. Richards presided, and at the second session, Mr. J. E. Johnson, Jr., was in the chair. The following papers were presented:

Does Forging Increase Specific Density of Steel? By H. E. Doerr. (Presented by title; written discussion by J. S. Unger.)

Flaky and Woody Fractures in Nickel-steel Gun Forgings. By C. Y. Clayton, F. B. Foley and F. B. Laney. (Presented by Mr. Foley; written discussion by O. A. Knight, J. A. Mathews.)

Static, Dynamic and Notch Toughness. By Samuel L. Hoyt. (Presented by the author; written discussion by P. D. Merica, G. Charpy, J. A. Mathews.)

Development of Grain Boundaries in Heat-treated Alloy Steels. By R. S. Archer. (Presented by title; written discussion by J. A. Mathews.)

Water-cooled Equipment for Open-hearth Steel Furnaces. By W. C. Coffin. (Presented by the author; written discussions by L. L. Knox, J. S. Unger.)

Prevention of Columnar Crystallization by Rotation During Solidification. By H. M. Howe and E. C. Groesbeck. (Presented by Dr. Howe.)

Basic Refractories for the Open Hearth. By J. Spotts McDowell and R. M. Howe. (Presented by Mr. McDowell; written discussions by J. S. Unger, F. R. Pyne.)

The Shimer Case-hardening Process. By J. W. Richards. (Presented by the author.)

Metallographic Investigation of Transverse-fissure Rails with Special Reference to High-phosphorus Streaks. By G. F. Comstock. (Presented by the author; written discussions by J. E. Howard, P. H. Dudley, W. R. Shimer, C. B. Bronson.)

Effect of Rate of Temperature Change on Transformations in an Alloy Steel. By H. Scott. (Presented by the author.)

Davidson Process of Casting Formed Tools. By J. E. Johnson, Jr. (Presented by the author; written discussions by Robert Grimshaw, J. A. Mathews.)

Session of National Research Council

The session of the National Research Council was begun on Wednesday morning, Feb. 19, and was continued throughout the afternoon. Mr. A. A. Stevenson and Dr. H. M. Howe presided. The following papers were presented:

Production of Ferromanganese in the Blast Furnace. By P. H. Royster. (Presented by the author.)

Effect of Cold-working and Rest on Resistance of Steel to Fatigue under Reversed Stress. By H. F. Moore and W. J. Putnam. (Presented by Mr. Moore; written discussions by J. E. Howard, J. B. Kommers.)

Use of Manganese Alloys in Open-hearth Practice. By Samuel L. Hoyt. (Presented by the author; discussed by E. R. Graham, H. M. Howe, E. Hibbert, F. N. Speller, H. Traphagen, and the author; written discussions by C. L. Kinney, Jr., J. R. Cain.)

A Volute Aging Break. By H. M. Howe and E. C. Groesbeck. (Presented by Dr. Howe.)

Report of Steel Ingot Committee, National Research Council. By H. M. Howe, H. S. Rawdon and F. H. Schoenfuss. (Presented by Dr. Howe.)

Microstructural Features of Flaky Steel. By H. S. Rawdon. (Presented by the author.)

In connection with this paper, there was a general discussion on Flaky Steel, involving also the paper by Messrs. Clayton, Foley and Laney, presented at the Iron and Steel Session on Tuesday morning. This discussion was participated in by: N. H. Wickhorst, L. F. Fry, C. B. Bronson, A. A. Stevenson, D. E. Field, J. A. Mathews, K. A. Pauly, H. C. Boynton, P. McKinney, H. D. Hibbard, H. Traphagen, R. J. Wysor, Leonard Waldo, A. H. Coles, J. E. Johnson, Jr., Boyd Dudley, Jr.

Mining, Milling and Geology

The session on Mining, Milling and Geology was held on Wednesday morning, Feb. 19, Mr. Charles W. Goodale presiding. The following papers were presented:

Mining Methods of United Verde Extension Mining Co. By C. A. Mitke (Presented by title.)

Study of Shoveling as Applied to Mining. By G. Townsend Harley. (Presented by title.)

Fine Crushing in Ball-mills. By E. W. Davis. (Presented by title; written discussion by A. L. Blomfield.)

Problems Involved in Concentration and Utilization of Domestic Low-grade Manganese Ore. By Edmund Newton. (Presented by the author.)

Notes on Certain Ore Deposits of the Southwest. By W. Tovote. (Presented by title; written discussion by Philip D. Wilson.)

Petrographic Notes on the Ore Deposits of Jerome, Ariz. By Marion Rice. (Presented by title.)

Anthracite Mining Costs. By R. V. Norris. (Presented by the author; discussed by E. W. Parker, S. D. Warriner, Edwin Ludlow.)

Work of National Production Committee, U. S. Fuel Administration. By J. B. Neale. (Presented by the author; discussed by Robert Peele, R. D. Hall.)

Distribution of Coal Under the U. S. Fuel Administration. By J. D. A. Morrow. (Presented by written discussion by S. A. Taylor.)

Session with American Institute of Electrical Engineers, on Electric Welding

This session on Electric Welding was held on Wednesday afternoon, Feb. 19, Dr. Comfort A. Adams presiding. The following papers were presented:

Microstructure of Iron Deposited by Electric Arc Welding. By G. F. Comstock. (Presented by the author.)

Path of Rupture in Steel Fusion Welds. By S. W. Miller. (Presented by the author; discussed by A. M. Candy, P. E. Horegood.)

Welding Mild Steel. By H. M. Hobart. (Presented by the author; discussed by A. M. Candy, W. L. Merrill, W. H. Alexander, W. Sparagen, Mr. Hunter.)

*Electric Welding in Shipbuilding. By S. V. Goodall. (Presented by the author; discussed by W. H. Hill, R. R. Horner, Capt. Corbett.)

*Fusion in Arc Welding. By O. H. Eschholz. (Presented by the author.)

SECOND ANNUAL MEETING OF THE WOMAN'S AUXILIARY

In the absence of the President, Mrs. R. Gemmel, Mrs. Louis D. Huntoon, First Vice-president, presided at the second annual meeting of the Woman's Auxiliary. The session on Tuesday morning was devoted

*Published in *Proceedings*, American Institute of Electrical Engineers.

to the receiving of the reports of the secretary, treasurer and auditors; the Central Americanization, Emergency and Foreign Relief Committees, and from the Section Directors of Arizona, Columbia, Missouri, New York and Utah.

On Wednesday morning, the following officers were elected: President, Mrs. James F. Kemp; first Vice-president, Mrs. Louis D. Huntoon; second Vice-president, Mrs. H. P. Henderson; third Vice-president, Miss M. P. Stone; Secretary, Mrs. Sidney J. Jennings; Treasurer, Mrs. H. K. Masters. The New York Section at this time also elected Mrs. W. Y. Westervelt as Section Director instead of Mrs. H. P. Henderson, who was elected second Vice-president.

The new President, Mrs. James F. Kemp, then took the chair, and in her inaugural address invited the organization to take Americanization as their work for the year. She urged that the Sections work together and increase their membership so that they become a real power and support standing behind the A. I. M. E.; that the directors take an active interest in forming branches and forwarding monthly reports to the Central Council for publication in the Bulletin; and that the women should urge their husbands to take home the *Bulletin* for them.

ADDRESS OF MRS. WM. D. SPORBURG

Wednesday morning, the vital importance of Americanization of the foreign-born and methods of accomplishing it were discussed. The discussion was opened by Mrs. William D. Sporburg, President of the Jewish Women's Council, Third Vice-president of the New York City Federation of Clubs, and a member of the Women's Committee of the National Council of Defense.

Years and years ago, just as a matter of human kindness and because we were interested in helping the strangers within our gates, all sorts of organizations were formed to help them, and of course since we have been plunged into war this subject has become a very paramount subject, something which we have had to take account of for very obvious reasons. My contention is that the great trouble with the women's organizations doing Americanization work in this country was that they did it from the standpoint of welfare work. You know we never looked upon them as quite up to our level, that is, while we did not look down upon them, yet we never considered the foreigners within our own group or our own status. We did do that as welfare work. Now, we have come to realize that the only way that we can really do effective, telling work with the foreigners is by stretching out a hand of real sisterly fellowship and making it clear to them that their contribution to America is as great as America's contribution to them.

We have some very serious things to consider. We have been told that there is not one piece of industry in the United States of America that could go on for fifteen minutes without the aid of foreigners, that factories and industries would have to be closed down if we barred foreign labor. We are absolutely dependent upon them. What we want to do is to really and truly assimilate them. There has been a great deal of talk about Americanization. We felt that the very standards of our country were in themselves a melting pot, that we could turn them out of this melting pot believing in the Constitution and waving an American

flag. We have learned recently that Americanizing a foreigner, expatriating a foreigner, and making him live up to the standards of our country, the country of his adoption is a very solemn thing. It is not a mechanical process at all. The mere fact that he signs Americanization papers does not mean that he is a real American in spirit. It is only when he accepts the standards for which America stands and believes in them that he is really, truly Americanized.

I have been perfectly horrified at the process of Americanization. Within the last two years or so we have given it a great deal of consideration. We know that in the courts where the naturalization process is going on that the actual final step itself has been treated with a great deal more solemnity and thought than has been given to it heretofore. I visited one of the courts with Mrs. Pennybacker. There were nine Italians standing in line waiting for their final test. The Judge turned to one of them (they are supposed to study up certain standards and be able to answer certain questions) and said, "Do you believe in polygamy?" The Italian looked a little nonplussed, poor soul, because I presume he felt he must not be anti anything, so he said, "Yes." The man sitting next to the Judge leaned over and said, "I don't think he quite understood that question. Do you believe in plural marriages?" The Italian still looked a little nonplussed, but he thought a moment and then he said, "Yes."

We felt the pathos, the real pathos of these men taking a step as solemn as an expatriation step without the full knowledge of what the obligations meant and what the standards of American life meant. I think that is a tremendous problem which we can help to solve. In the interim between the time they take out the papers and the final test we can teach them our language and help them understand these things, help them understand what real citizenship means. And the way to help them to understand is to make them as familiar with the English language as possible. It also gives them an opportunity to understand us and it gives us an opportunity to understand them. We are going to make them realize what American standards are by our own actions, by the example we set—for that is the thing that is going to be followed most closely, the example and precept of our own lives. If we American women will conduct ourselves in a thoroughly American spirit, the foreigners are going to imitate us very quickly. We must point the way to them, showing them loyalty to Government institutions, loyalty to the people who are elected to represent them in those institutions, which does not mean, women, when the people themselves have put men in power, whether it is the Presidency or a Governorship of state, Mayor of municipality or even the lesser offices, it does not mean that loyalty, respect and support of them bars us from honest criticism, because we need honest constructive criticism, but we must not fall into pitfalls and object and criticise men in power on partisan issues, whether we are Republican in tendency or whether we are Democratic in tendency, we should never believe that an issue, which is an important issue, and in which we can rightfully believe, is not a good issue because a Republican or a Democrat has stood for that particular measure. We must think and vote on measures on their face value. And when foreign-born men and women see us doing that, it is going to be one of the best forward steps in real Americanization that can happen.

We ourselves, we Americans, must be educated to the proper spirit

of Americanization. We must be thoroughly American and in dealing with the foreigners in our ranks we must do it with toleration for each other and with mutual understanding.

I come from a very small community; there are about 14,000 inhabitants in Port Chester of whom 71 per cent. are foreigners. Twenty-two nationalities are represented. Through our district nurse, who gets the confidence of these people, we get together, once every two weeks, a group of these foreign-born mothers. At the first meeting we had eleven different nationalities and I certainly thought the Irish woman would scratch out the eyes of the Italian woman. The second and third time they became just a little more tolerant of each other and now there has grown that splendid understanding, that though they are different and apart, they have traditions and things and ideals that are worth while. They are working in harmony. I think that is the solution—we must tolerate each other and we must tolerate different conditions.

We have no right to go to an Italian, Greek, Russian, or anybody else and say, "Here, America offers you everything. You must forget everything else that has ever happened in your life, you must forget your folk-songs and everything about your country." If we make them realize their traditions are beautiful that we respect them just as we want them to respect us, we will accomplish a great deal. We must make them appreciate that we are going to be helpful to each other and that they mean as much to us as we mean to them. We want them to become Americans not only in name but in spirit.

I want to impress upon you that you must not depend on your Chairman of the Committee to do your work, no matter how efficient she may be; each individual must feel that you have a very important part to play in your organization and in your own community. You know very well that the war has taught us that lesson that it is the spirit of cöoperation that counts. We think with dread upon what might have happened to England if she were warring with Germany alone, we know what would have happened to France if she had been alone, we know what happened to Belgium and we know what might have happened to America and we know what happened by coöperation and organization. If every woman would get in back of just one immigrant family, think of the tremendous amount of good. Your individual effort counts.

In the discussion that followed, Mrs. Sporburg said that the employment of the district nurse is the most practical method of starting this work of Americanization. The foreigner is a little bit suspicious, she wonders if you are coming to buy the wage earner's vote or to disturb the routine of her housing methods. But a district nurse, a woman who comes to these people in times of trouble, gets their confidence. We have found that the most effective work we can do in smaller communities is through the nurse. She knows their problems and they trust her, and she leads them to the other people in the community who are ready to work for them.

A MEMBER.—I have had considerable experience with that and I have found that the women do feel that you are trying to influence them or trying to get the better of them—they cannot understand why American women are trying to get into their houses. What would you suggest in New York City outside of working through settlement organizations or through large organizations? How would you suggest that the individual should go about it.

MRS. SPORBURG.—I firmly believe in organized effort. Frank Lane is now planning a nation-wide unified program for Americanization. Congress has a bill to appropriate $500,000,000 for education. I do believe, aside from following a program of organized effort, that individual effort does count. I lived in New York City before I ever thought of myself in connection with this work and I was intensely interested in the Italian who had a fruit stand on the corner. I was interested in others, I went right into their homes and worked with them. I made them feel that at any time there was a problem in their lives that they could come to me and I would help them to the best of my ability; whether it was the man drinking or the child who was becoming so Americanized that it poked fun at its foreign mother—which I think is indeed a tragedy. I think it is an indictment against us that we have neglected the foreign mother so long. The foreign father gets his Americanization through industry, through his contact with the business world and the child gets his through the school.

A MEMBER.—In doing some work in New York City during the food conservation period I came across several cases where the children could not speak with their own mothers. Another thing, do not you think there is a danger in becoming over-organized—that over-organization tends toward destroying individual effort and initiative and that it has a tendency to destroy just as it destroyed the soul of Germany?

MRS. SPORBURG.—There is always a danger, but I think if the individual women will work from a personal standpoint they will avoid that. But there must be some organization, otherwise there would be such a lack of efficiency that a good deal of time would be wasted. As I said before, I think it is tragic that the foreign mother cannot speak the English language. Very often the foreign men especially the Italians, do not allow the women to leave their homes. They think her place is in the home and, before the franchise was granted, they were afraid she would have too much right. To overcome that and bring about confidence, in New York City, groups of women meet in one another's homes, and in that way they come in touch with the problems of the other woman, whether it is the food question, the question of citizenship, or the question of an unmanageable child, or whatever it may be.

A MEMBER.—Your feeling then is that at the present time the greatest need lies with the mothers. You feel that the children and fathers have had, so to speak, their share in a way through schools and agencies which are already established?

MRS. SPORBURG.—Yes, through unconscious contact with business and the people around them in business they learn certain things about the American standards.

A MEMBER.—If you were supporting any new work your feeling would be to largely get in touch with the mothers and leaving the children and men to what is already started?

MRS. SPORBURG.—My first step would be to bring up the status of the mother to that of the child and father.

A MEMBER.—What is needed now is to bring the mother up to the level of the children and the father.

MRS. SPORBURG.—My experience has been that. As I said before it is appalling, it is an indictment against us that something has not been done before to educate the foreign mothers. Do you know there were 700,000 soldiers in the American army who could not read nor write

English? Do you know that some of that 700,000 were American born, southern born, who never had the opportunity of obtaining an education? There are 400,000 women in New York state who cannot read, write, nor speak the English language and there are 300,000 who cannot read nor write any language. I say it is an indictment against us women to allow such conditions to exist.

A MEMBER.—You were telling us about the gatherings where the Irish woman came to understand the Italian woman. Would you tell us how you conduct those gatherings?

MRS. SPORBURG.—Through the district nurse an invitation is extended to the various women she visited. It could be extended through other agencies if you have no district nurse. Our district nurse, when visiting these women would say, "At my rooms"—which is in the heart of the village—"on Thursday afternoon we usually have a little party. We have some clothing there which has been given to us by people who no longer need it. You are welcome to come and see if there is anything there you want. You can bring your child, or if there is anything in your own home you want to make over and need some assistance on, bring it along and we will help you." That is the way to get the group together and ostensibly they come to sew. In that way they get in touch with one another and become more tolerant of one another. You know there are always feuds between these various little colonies.

I would like to cite an instance: Last year in our desire to help the Food Administration, we had in Port Chester, as they had in many communities in West Chester County, the problem of dehydration. We all learned about using substitutes and swapping receipes that had proved successful (we did not say much about those that were not successful) but when it came to the subject of dehydration we were very much puzzled, they told us that even the commercial institutes were not particularly successful. I remembered one day the large rows of red peppers and onions, etc., that I used to see while driving through the Italian colonies. I drove down there and told these women to come to our demonstration, I said you can probably help us because your boys are in the service with our boys, they are all fighting together, and we are all going to stand together with hands outstretched. We can tell you a great deal about certain flours and things and I am sure you could tell us something about drying foods. We got an Italian woman to demonstrate their process and she was more successful than any woman who had made a study of it for eight years in Cornell. If you make them appreciate their contribution as well as ours they are willing to help. If you want any woman to think your way you do not approach her with a hammer, make as gracious and as kind an approach as you possibly can; it is the understanding heart of the woman who is doing that work that really truly counts.

A great many of the foreign-born women signed the food cards, not knowing what they were signing—they never refused a food pledge. I made a test of this one time and I went from house to house and out of all the places only one woman stopped to ask me a question. I did this simply as a test. They are frightened stiff when you say you are from the Government and want them to sign a pledge. It is absolutely the wrong way to approach them.

A MEMBER.—I want to know how you would deal with a woman who was not born here but who has lived here a great many years, who would

not sign a food card, claiming that she did not think the Government had done her any good, saying, "I can scarcely make a living, foods are frightfully high, and I cannot see that the Government has done anything for me why should I sign that? I have given much more to the Government than the Government has given to me."

MRS. SPORBURG.—I would immediately say, go back to the country from which you came.

A MEMBER.—She says she cannot afford to do that.

MRS. SPORBURG.—I would have seen to it that the money was collected to deport her. People of that class are very dangerous, they have very radical doctrines. I would first try every means that I possibly could to give her a thorough understanding and if I could not get her to understand I would see the Commissioner of Immigration.

REPORT OF TREASURER OF WOMAN'S AUXILIARY

RECEIPTS		
Balance on hand year beginning Feb., 1918	$226.20	
Entrance fees and dues received during the year ending Feb., 1919	65.10	
Total		$291.30
DISBURSEMENTS		
Stationary, printing, etc	$27.75	
Secretary's expenses—typing, postage	48.85	
Money refunded to Sections on dues	17.00	
Total expenditures		$ 93.60
Balance on hand		197.70
		$291.30

MRS. HARRIS K. MASTERS, *Treasurer.*

REPORT OF EMERGENCY COMMITTEE

This Committee was formed with eighteen members in addition to the Chairman, the Treasurer, Mrs. Karl Eilers, and the Secretary, Miss Olga Ihlseng, in March, 1918, and owing to the cessation of hostilities its activities ceased last December.

Two knitting machines were purchased and installed in the Ladies' Reception Room in the Engineering Building, which room was placed at the joint disposal of this Committee and the Foreign Relief Committee through the courtesy of the United Engineering Societies.

During the period of its activities your Emergency Committee obtained 550 pounds of wool and material for 72 wool cloth sweaters purchased from funds supplied by Mr. R. W. Ingalls, Treasurer of the Comfort Fund of the Association of the 27th Engineers.

Thanks to the energies of the members of the New York Committee and their friends, and also the Salt Lake City, Colorado, and Columbia Sections, 170 sweaters, 773 pairs of socks, 89 wristlets, 85 helmets, 24 comfort kits, and 3 mufflers, were provided for the Comfort Fund.

To raise funds for general expenses a Concert was held in April, the return from which will be noted on the attached Treasurer's Annual Report.

It was with the deepest regret that your Committee learned of the death of Mr. A. L. Gresham, who gave his untiring assistance to your Committee since its inception.

LAURA M. SPICER, *Chairman.*

REPORT OF TREASURER OF EMERGENCY COMMITTEE

Our income was $204.01 and our expenditures were $41.05, leaving a net cash on hand as of December 31, 1918 of $162.96.

RECEIPTS

April 30	Mrs. Spicer concert	$167.21	
April 30	Mrs. Thurston (donation)	5.00	
April 30	Donation concert	2.00	
May 10	Mrs. Prosser concert	2.20	
May 20	Mrs. Porrier concert	2.20	
May 20	Miss Stone concert	11.00	
May 20	Stationary refund	10.00	
July 20	Geo. A. Schroder concert (Mrs. Spicer)	4.40	
	Total receipts		$204.01

EXPENDITURES

April 30	Olga K. Ihlseng (postage, etc.)	$3.37	
May 13	Mrs. H. Hardinge (postage, etc.)	2.17	
May 13	Mrs. Mann (addressing and mailing)	5.30	
June 28	Olga K. Ihlseng (postage, etc.)	1.94	
Sept. 27	Collector Internal Revenue (concert)	27.20	
Nov. 8	Marion M. Shields (postal cards)	1.07	
	Total expenditures		$41.05

MRS. KARL EILERS.

REPORT OF THE CENTRAL FOREIGN WAR RELIEF COMMITTEE

The Foreign War Relief Committee has been very active during the past year, raising funds to the amount of $6207.11 for the relief of devastated France. Reference to the Treasurer's report will show that $5686.51 was disbursed through the American Fund for French Wounded, at a total operating cost to the Foreign War Relief Committee of $331.60. Four war lectures were given to provide funds for the operating expenses of the committee, and every dollar raised by subscription was sent to France for relief work. $966.00 was contributed for the purchase of sheep for stocking reclaimed districts in France, this sum being disbursed through the civilian committee of the A. F. F. W.

Early in May, the Foreign War Relief Committee, Mrs. Henry H. Knox, chairman, carefully considered the various channels for relief in France, and launched the project of establishing a dispensary there for the care of women and children. How this work prospered has been told in reports from time to time, but it may be repeated that $3000 was sent to France and a dispensary bearing the name of the New York Section of the Woman's Auxiliary to the A. I. M. E. has been established at Briey. The committee closed its dispensary fund in January, with a contribution to the American Fund for French Wounded of $1720.51, to meet their urgent need for emergency dispensary work among the refugees returning to certain distressing centers.

Tuesday was established as "Engineer's day" at headquarters of the A. F. F. W. The committee has had six full working days and two half days there, and Mrs. Percy E. Barbour, director of work room, reports an enrollment of twenty workers. The average attendance was ten; largest attendance for any one day, thirteen; smallest, eight.

Finished garments turned in to the A. F. F. W. include thirty-nine hospital robes and eight children's garments. Contributed to this work—one infant's layette, three pairs shoes, ten refugee garments.

Mrs. J. P. Hutchins reports that letters received from the mothers of the four fatherless children, war orphans of France who were adopted by the Woman's Auxiliary for two years, express sincere appreciation of what has been done for them. Photographs of the little ones indicate that they more than merit the help which they are receiving.

FINANCIAL REPORT FOREIGN WAR RELIEF COMMITTEE OF NEW YORK SECTION

RECEIPTS

Funds raised to meet operating expenses of the Committee:		
By four war lectures	$515.60	
Contribution	5.00	$520.60
Funds raised for purchase of sheep for stocking reclaimed districts of France. Disbursed by Civilian Committee, American Fund for French Wounded:		
By subscription		966.00
Funds raised for French dispensary work. Disbursed by American Fund for French Wounded:		
By subscription		4,720.51
Total receipts		$6,207.11

DISBURSEMENTS

Operating expenses of Committee:		
Four war lectures	$129.36	
Printing, postage, etc.	53.04	
Raising sheep fund	22.67	
Raising dispensary fund	112.74	
Work room charges	13.79	$331.60
Donated to sheep fund of Civilian Committee, A. F. F. W.		966.00
Donated for dispensary at Briey, France, under name of Woman's Auxiliary		3,000.00
For maintaining dispensary work		1,720.51
Total disbursements		$6,018.11
Balance in bank		$189.00

REPORT OF THE CENTRAL AMERICANIZATION COMMITTEE

During the Spring of 1918, the Chairman of the Committee held various meetings among the foreign-born women, living on the East Side. These were discontinued during the Summer, when considerable work was organized and supported on Long Island among the various factories, several addresses being arranged for during the noon hour.

In the Fall, Americanization work was continued at the various Settlements in the Greenwich Village Section, much helpful constructive work being done duing the recent influenza epidemic in advice to the foreign-born women, as to better methods of caring for their families.

The Committee has been able to get in close touch with the foreign-

born families during the past month in connection with the City's "Back to School Drive." Many of the foreign families not realizing the importance of their children remaining in school until the age of sixteen, nor the advantages thereby gained, until presented to them by members of the Americanization Committee. Such Committees would prove of great assistance to teachers in all parts of the Country, as they could visit the families of delinquent children, and ascertain the cause of the delinquency, thereby getting in personal touch with these families.

With the signing of the armistice began a new era for America. We stand as never before in the eyes of the world and the duty of every American should be to consider themselves a member of an Americanization Committee.

LAURA G. BURGER, *Chairman.*

LADIES ENTERTAINMENT AT THE MEETING

Immediately after lunch Monday noon, the Ladies' Committee entertained the visiting ladies in a short but very interesting sightseeing trip—first to Columbia University; then to the Cathedral of St. John the Divine; Grant's Tomb; the American Museum of Natural History, where the building being closed after hours to the public, was given over entirely to the ladies. After inspecting the exhibits, particularly those of precious stones and the mine model of the Copper Queen mine, the ladies were entertained at a very elaborate tea in one of the halls of the building. About one hundred ladies were present.

A novelty of this sightseeing trip was that private automobiles were supplemented by double-decked Fifth Avenue 'Buses for conveying the party over the route. The weatherman had been subsidized by the Ladies Committee and the upper deck of the bus was much in demand by the visitors.

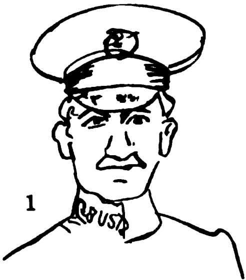
On Tuesday afternoon, February 18, about 100 ladies visited the art galleries of Senator W. A. Clark, who has so frequently opened his collections to the Institute on former occasions. After inspecting the galleries, tea was served.

On February 19, the ladies were entertained at a theater party at the Gaiety Theatre, where "Lightnin" was very much enjoyed.

A large number of ladies attended the evening entertainment Tuesday, February 18, and the trip to the Federal Shipbuilding Plant on Thursday, the 20th, which are mentioned in more detail elsewhere.

THE SMOKER

The annual Smoker of the Institute was held in the rooms of the Engineering Societies' Building Monday evening, Feb. 17, and was attended by about 400 members and guests. Mr. E. P. Matthewson was Chairman of the Entertainment Committee, and produced one of the most varied and interesting—not to say exciting—programs provided for any of the Smokers. Patriotic and other songs comprising largely the favorites in the Army today, were sung. The members were seated around small tables decorated with the college flags, and laden with refreshments. A cartoonist made rapid-fire charcoal sketches of promi-



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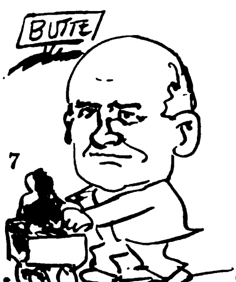

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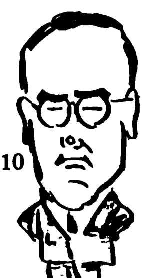
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CARTOONS MADE AT THE SMOKER BY OUR LIGHTNING SKETCH ARTIST.

1. Major Arthur S. Dwight, with his fighting face, or What made Germany quit. 2. George D. Barron, who finds that cactus is not all that can be raised in Mexico. 3. Mark L. Requa—the only man who ever stopped all the automobile traffic on Fifth Avenue. 4. Horace V. Winchell—our incoming President coming in. 5. J. E. Johnson, Jr.—alleged to have books to sell. 6. George C. Stone—touring Australia on a kangaroo. 7. B. B. Thayer—who believes in having the cars full. 8. Sidney J. Jennings—our retiring President, The noblest Roman of them all. 9. W. R. Ingalls—the distinguished editor of the *Engineering & Mining Journal*. 10. Bradley Stoughton—the first Secretary of the American Institute of Mining and Metallurgical Engineers. 11. Herbert C. Hoover—the most talked of man in the world. 12. E. P. Mathewson—hit by a new idea.

nent members of the Institute, which were so cleverly done that the identification was made before each sketch was completed. Remarks by the cartoonist added to the appreciation of the sketches themselves. Some of these sketches are reproduced herewith.

Following this, Mr. Mathewson called to the platform various members of the Institute whom he accused of having violated some parts of the professional code of ethics. B. F. Tillotson of the New Jersey Zinc Company, after a very severe and very humorous castigation, was turned about to look at a colored geological map of New Jersey, which had been posted during the talk. The peculiarity of the formation and the colorings applied gave the map the appearance of a woman, which furnished a climax to Mr. Mathewson's oratory. George C. Stone was the butt of the next joke. A life-size cigar advertisement, which had been carefully brought by one of the members from Colorado, was placed beside our erstwhile treasurer and looked like his twin.

A lithographed advertisement of one of the best-known hair tonics was hung up. The striking likeness of the bald head, the fringe of curly hair, and the nicely pointed mustache, to which this tonic was being applied, was almost as good as a photograph of J. Parke Channing, so the three guesses given by the Chairman were entirely unnecessary. As a matter of fact, this sign has been such a striking likeness that the Entertainment Committees for several years have been trying to invent some excuse for ringing it in at a smoker.

Following this, were various new and novel films: among them one showing the interior mechanism of an automatic adding machine at work, and a most interesting one showing in section the workings of the Lewis machine gun.

It was the largest and most successful smoker ever held by the Institute, and if Mr. Mathewson were not such a good metallurgist, he would have been an equally famous purveyor of amusements.

LIEUTENANT PAT O'BRIEN

On Tuesday night, February 18, to an auditorium filled with members and lady guests, Lieutenant Pat O'Brien, formerly of the Royal Flying Corps of Canada, the United States Army, and the French Foreign Legion, gave a vivid and intensely interesting description of his flying exploits, which landed him wounded and unconscious inside the German lines; of his life in various German prisons and prison camps; and of his successful escape to England, through Luxemburg, Belgium, and Holland. Lieutenant O'Brien's marvelous escape after a fall of 2000 ft., after which the wreckage of his machine had to be cut away in order to extract him, was even more thrilling when told than as written in his book "Outwitting the Hun," which is his published story of the episode. His recital of how he executed a daring plunge through the window of a train loaded with prisoners running at 30 miles an hour; how it took him seventy-two days, or rather nights, to cover 300 miles to the Dutch border; how he lived on raw vegetables, swam rivers and canals, and finally dug under the highly charged barbed wire barrier between Belgium and Holland, as well as the many instances of grim humor with which his speech was interspersed, brought many bursts of applause from a highly appreciative audience. At the conclusion of the speech,

ANNUAL BANQUET OF THE AMERICAN INSTITUTE OF MINING ENGINEERS AT HOTEL BILTMORE, FEBRUARY 19, 1919.

many of the audience went to the fifth floor, where an informal dancing party was held, during which ice cream, cake, and punch were served. It was a bit different from the other evening entertainments provided for the members and ladies, and was an unusual success.

THE ANNUAL BANQUET

The annual banquet of the American Institute of Mining Engineers was held at the Hotel Biltmore on Wednesday evening, February nineteenth. The dinner was preceded by the President's Reception, Mr. and Mrs. Horace V. Winchell and Mr. and Mrs. Sidney J. Jennings receiving. The ballroom was beautifully decorated with flags of the Allies and the electric sign of the A. I. M. E. There were 450 members and guests present, and it was the largest and one of the most enjoyable of the dinners ever held by the Institute.

An innovation in the dinner arrangements was cutting the list of speakers to three, who were the President of the Canadian Mining Institute, and the retiring and incoming Presidents of the American Institute. The speeches were all short and very interesting.

The menu cards had on their cover the cartoon which is reproduced on another page. George Washington hatchets and other favors, and a plentiful supply of toy balloons added gaiety to the occasion.

After the dinner, a larger number remained for the dance than heretofore, and dancing was indulged in until the wee small hours of the morning. There was a large sprinkling of French, Canadian, and American uniforms which with the many beautiful and elaborately gowned ladies made it the most brilliant affair of its kind the Institute has ever given.

MENU

Blue Point Oysters
Velouté Favorite
Celery Salted Almonds Olives
Halibut Steak, Italian Style
Risotto Joinville
Roast Philadelphia Capon Chaructière
Salad Parisien
Nelusko Praliné
Cakes
Demi Tasse

TOASTMASTER'S REMARKS

Each speaker was introduced by the toastmaster Lawrence Addicks who said:

In this great year of victory it seems but fitting that we, as members of the *American* Institute of Mining and Metallurgical Engineers should first rise in response to a toast to America. America was then sung by all.

My instructions from the Dinner Committee were exceedingly brief. They consisted of three or four typewritten lines reading: "You will have three speakers to introduce—Mr. Dowling, Mr. Jennings and Mr. Winchell. Do not let any of them speak long, give each of them a good rub, especially Winchell, and do not say much yourself." The last line


RICKETTS
MOORE
MATHEWSON
JENNINGS
SAUNDERS
KELLEY
RYAN
THAYER
STONE
BARRON
STOUGHTON
GOODALE
MENU
WINCHELL
MINING LAW
Annual Banquet of the AMERICAN INSTITUTE MINING ENGINEERS
HOTEL BILTMORE FEBRUARY 19-1919

leaves me much in the position of the young husband who looked adoringly at his wife and said: "Dearest, I do worry so when I think what would become of you if I should die." "Why," she replied, "nothing would happen to me; I should stay right here; the real question is what would become of you." So I shall proceed with some caution.

As the smoke of battle clears away, we begin to see that the war has not been wholly a thing of evil. The ladies, in a new sense, have become our companions in arms; and as peace on earth is reëstablished we find an added measure of goodwill toward men. The Allies have been bound together not by the ties of mere political expediency but by those of a true blood brotherhood. This is especially true of the English-speaking peoples and of the United States of America and her near neighbor Canada. Some of us make frequent trips across the border and we know with what uniform cordiality we are received. Our worthy president here about two weeks ago came near making an unannounced visit to Canada. You know he is very fond of horseback. He has a theory that there is no place where a man can think so clearly as on the back of a horse; and, like ex-president Taft, he does not care what the horse thinks. Well, as I have it, Allen Rogers and Galen Stone were standing outside of Mr. Rogers' house in Brookline discussing flotation of mining stocks. All of a sudden Mr. Jennings comes tearing down the street on a horse, with one foot in the stirrup and both hands buried in the animal's mane. "Hey," Mr. Rogers called out, "where are you going?" From the distance Mr. Jennings cried: "I do not know, but the horse belongs in Montreal."

We in our turn have always been glad to see the delegation from the Canadian Mining Institute who have made a practice of attending our annual meetings for some years past. But I think that it is with a new feeling of fellowship that we welcome them this year and it is in this spirit that I greet Mr. D. B. Dowling, president of the Canadian Mining Institute and ask him to say a few words to us.

At the close of this speech, he said: It has long been the custom at these annual meetings to afford an opportunity for the retiring president to sing his swan song, and it is always hard to break old customs. You know they say whenever you put a tractor on a farm the hired man quits and when you ask him what the trouble is, he says, "Wal, fer 20 years I been tryin' to learn to understan' a mule and at my time of life I don't intend ter take on this new fangled thing." Now for 20 years we members of the Institute have been trying to learn to understand these farewell orations and we do not intend to give up now. Some of you may think that the words and music of this song are to be found in the Secretary's annual report in the current issue of the Bulletin, but I assure you that this is not so. It does grave injustice to the responsibilities of the office of President of this Institute. Let us just consider for a moment his manifold duties.

First, his foremost duty is to bring the membership of the Institute up to the point where the incoming President will have to rely solely upon the birthrate of the population. Second, and this is most important, he must devise some solemn stunt with which to make the annual attempt to coax the Mining and Metallurgical Society into the fold. Then, he must make a semi-annual tour of the provinces to visit all of the Local Sections and deal with incipient cases of heresy and schism, diseases that appear to be endemic in Southern California and Southeastern Missouri

Next, ex officio, he has to try to keep the peace between the Editor of the *Engineering and Mining Journal* and the Editor of the *Mining and Scientific Press*. Finally, this year there was a matter of the attitude of the Board of Directors toward the prohibition amendment—a most serious question.

However, while there may still be a few citizens not yet members of the Institute, who will have twelve dollars after March 15th, and while the Mining and Metallurgical Society may still claim to represent the certified, pasteurized, grade A variety of mining engineer, this Institute has never had a more successful year than under the able administration of Mr. Sidney Johnston Jennings, whom I now have the pleasure to introduce.

Unfortunately Mr. Dowling left for Canada and Mr. Jennings left for Mexico before the manuscripts of their speeches could be received.

In introducing the last speaker, Mr. Addicks said: We are living in strenuous times. Governments are being overthrown every day. In fact I understand that the President even now is hurrying home from France on account of rumors that a republic is about to be declared in Washington. So it is not strange that the Institute itself has decided upon a radical, nay a revolutionary, step. It has placed the seal of its approval upon mining geology.

The geologist has had a hard time of it. You would think that a man who had made the study of rock formation and ore deposits his life work, would be the ideal person to send out prospecting. Great mines have been discovered by bartenders, by livery stable keepers, by one, or perhaps two, Columbia graduates, but by a mining geologist, never. If you already have a mine, he will make a beautiful map of it, all in colors, for he has an artistic soul, with the quartz in blue and the limestone in yellow, and the ore as a red streak in between. He will show you that if you drill a hole over in the next lot while your neighbor is at the seashore, you will discover an extension of the vein. You try it and find the limestone where the quartz ought to be, the quartz where the lime ought to be, and the ore vanished altogether, and then go to your geologist, he will coolly meet the ascending waters of your wrath by taking his pencil, drawing a line across the map and writing "faults"—meaning the fault is nature's and not his. "Well," you say, "if a geologist cannot discover a mine and cannot develop a mine, of what good is he?" I will tell you. If you have a really good one, and he really likes you, you take him into court and he can prove *anything*.

An old gentleman was coming down the street and saw some colored boys shooting craps. "Rastus, don't you know that it's just as wicked to gamble when you win as when you lose?" "Yessah, yessah, de immorality am jes as great but the inconvenience ain't." Well, what is the use of my discussing this ethical question when the Institute has settled the matter by electing as its next president the very best mining geologist in the whole city of Minneapolis, Mr. Horace V. Winchell.

PRESIDENT WINCHELL'S SPEECH

I am told that it is customary on the recurrence of this annual event, for the incoming President to present for your consideration and that of the members at large a few thoughts as to the work of our Institute, and the industry which it is supposed to represent; to sound the key-

note of progress for the coming year and to direct attention to the work of the hour.

If this be already a custom, it is something for which neither you nor I can be held responsible, and yet something which neither of us can escape. It is therefore my duty and high privilege to prepare the dose, and yours to take it as gracefully as possible, in the full belief that what is customary is proper, and what the doctor prescribes is beneficial, though not always palatable. In this case I trust it may be both.

It is a trite saying and a true one that we are living in the most wonderful period of history. We are witnessing the evolution of a new order of things. We are participants in movements which are everlasting in their effect and world wide in their scope. Forces and activities now set in motion will have their influence on the human race throughout its entire period of existence, and the lustrum of time of which 1919 is the closing year will be forever marked in red and gold on the pages of history.

It is entirely proper for us to reflect with pride upon the service which our Institute and its members have rendered the cause of humanity in the recent conflict. The names of those who have given their money, their time, their efforts, and in many cases, their lives, will ever be held in honored memory. But it is not sufficient to complacently remember the past. Our work is still ahead, and it is timely for us to consider our relation to our profession, to our country and to ourselves in the working out of the problems of the future. What part are we able to play in reaping the benefit which should and must accrue from the sacrifices of the world since 1914? Is there any work which the engineer is better qualified than any other class to undertake? Is he now already preparing in true engineering fashion to get 100 per cent. efficiency out of himself and his organization? As educated and reasoning citizens of the world's greatest democracy, as trained engineers, as members of the American Institute of Mining and Metallurgical Engineers, what can we as individuals and as an organization do, what are we morally and in a sense of reciprocity obligated to do, under the new conditions with which we are confronted, to improve our own situation and that of all mankind?

The answer depends on the nature of the problem and the conditions with which it is surrounded. Do we fully realize the momentous changes which have already taken place? A nation which was taught by Washington to avoid foreign entanglements has in the interests of self-preservation been forced to take an active part in the settlement of a war in Europe, and is now occupying a prominent seat at the council of nations. Within a single twelve months we have abandoned the policy of our forefathers and become an arbiter and co-administrator of the affairs of all countries. Never again can we pretend to stand aloof and unconcerned while war flames are kindled abroad. No longer can we afford to be provincial. The ocean now is narrower than was the English Channel before the construction of telegraph lines, steamships, submarines, and airplanes. The food supplies, the raw materials, the factories, the mines, the schools, the people of foreign lands are now subjects for our careful study and consideration. We are and shall be impelled to it by motives of every variety, materialistic and humanitarian. The better we understand the world and its problems, the more successful we shall be in our commerce, in the development and handling of our internal

affairs, our finances and our labor questions, our crops, our mineral production; everything that concerns our prosperity and welfare.

Then, too, from a nation of borrowers, needing foreign capital to develop our resources and owing vast sums upon which we were paying interest to the bankers of Europe, we have suddenly by fortune of war become a creditor nation. The nations of the world owe us inconceivable sums. The interest on our loans abroad would have paid the entire expense of our national government when we men were youths. This change in our status is of tremendous importance to the engineer, whose field of operations has thus suddenly become widely extended. The first and immediate demand for engineering talent probably lies in connection with the problems of restoration and reconstruction in the devastated areas. To what extent American engineers will be used in this work depends largely upon the supply of materials of construction and of engineers in Europe and upon the ability of our trans-Atlantic neighbors to finance their operations without our aid. In many districts, mines and manufacturing plants have been destroyed; in others, worn out; in most cases on the Continent, production has been pushed to the maximum without stopping for repairs; railroads and highways have been worn unceasingly, and must need renewing. And in addition to this plant and material exhaustion, it must be remembered that there has been appalling loss of life among the engineers and those of sufficient mentality to make army officers. Increased and intensified demand for materials and a shortage of designing and constructing engineers would seem to create unprecedented opportunities for this country of matchless resources in both. And here is where the advantage of the United States as an opulent and creditor nation becomes doubly accentuated. Now for the first time in our history we have more money than we can spend at home; now the wide world is our field of operations; now we are compelled to search for development enterprises in which our surplus capital may be employed; now we must, in spite of ourselves, become cosmopolitan. And since those very countries which are our debtors are the ones which most need our assistance, it is only by increasing our business with them and our investments there that those debts will ever be paid. By enabling them to rebuild, by establishing them again on a prosperous basis we shall at the same time protect the investments and loans already made under the necessities of war. Does this situation not promise work and opportunity for the engineer?

But the war has brought other changes. The employment of man power and materials for the sole purpose of destruction has been so general and widespread as to change living conditions over a large portion of the inhabited globe. Economic laws have been arbitrarily set aside, and the governments have been compelled to establish artificial prices and regulations for the transportation and allocation of labor and materials. The inevitable result has been dissatisfaction, uncertainty, and confusion. The workman who has recently been receiving fifty dollars per week instead of the former twenty-five cannot understand why there should be any reduction now that the war is over. The farmer still wants war price for wheat; the southern planter wants war price for cotton; and the field hand still desires to work half time and get double wages. On the other hand there is a general desire for a reduction of the cost of the every day necessities of life. In short, we are faced with a condition of unrest and uncertainty in all quarters of the globe. Every thoughful

person knows that there must be readjustment, but no one can foresee its precise trend and effect. Is there not here again a demand for the influence and effort of the intelligent engineer?

Those of us who have watched the spread of Marxian socialism abroad, who have seen its adoption by the Russian Bolsheviki and have seen their poisonous propaganda insidiously inoculating the workingmen of Russia, Austria, Germany and even England, and who have read the anarchistic publications of their disciples in this country cannot but feel that it is high time something was done to counteract it. Bolshevism is the antithesis of democracy; it is the foe of freedom; it is a rule by a class, and that class the most ignorant and least civilized in the community. It matters not whether it be found in the parlor or in the revolutionary parade, in the poisoned press or on the street platform, bolshevism is an abomination subversive of order and government, and must be opposed by every patriot and loyal citizen, by every influence and power which desires the welfare of mankind.

It has often seemed to me that the engineer is not fully awake to his duties and privileges as a citizen; that he is too engrossed with the details and the mechanism of his profession; that his mind dwells too much on facts and figures and processes; that he is too retiring by training and disposition, too little of a publicist and a humanitarian, and too much of a materialist. I believe that individually and through his organizations he should take an active part in every movement that concerns the good of society; that he should take the initiative in shaping the policies of government; that he should be an aggressive educating and moral force in every community.

On his visit to this country in 1876, at the founding of the Johns Hopkins University at Baltimore, Thomas Huxley addressed us as follows: "Truly America has a great future before her—great in toil, in care and in responsibility, great in true glory if she be guided in wisdom and righteousness, great in shame if she fail. I cannot understand why other nations should envy you or be blind to the fact that it is for the highest interest of mankind that you should succeed; but the one condition of success, your sole safeguard, is the moral and intellectual clearness of the individual citizen."

In all branches of business, in all lines of human endeavor, we have been taught to strive for efficiency. Indeed, so greatly has the idea been stressed that we have been in danger of regarding it as an end in itself. We have forgotten why we are thus striving. We have often had our attention directed to the efficiency of the German people as something well worth imitating. Dr. Nicholas Murray Butler, in a most scholarly address on "Education after the War,"[1] has given us a timely warning: "The war has taught the lesson that the proper place of efficiency is as the servant of a moral ideal, and that efficiency apart from a moral ideal is an evil and a wicked instrument which in the end can accomplish only disaster. In other words, we should encourage efficiency not for its material results, not simply for the greater amount of wealth in dollars and cents, in bushels of wheat, tons of ore or yards of cloth thereby produced, but for its value in the development of character, and for its aid in the achievement of our ideals and the guidance of the individual and

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[1] Educational Review, Jan., 1919.

the race in their progress toward fuller self-expression and more complete self-realization."

Now, the only road to efficiency is education. In all departments of life, in business, in government, in commerce and trade, education must precede efficiency, and the broader and more widely disseminated the real education of a people, of a class, of a community, the higher its efficiency. And this brings me down to the suggestions which I wish to make this evening.

Scarcely a day passes that the newspapers do not contain notices of strikes, of lockouts, of labor dissatisfaction and disturbances in this or that industry. The strife between the employer and the laboring man is incessant and irritating to both. It is world-wide and apparently everlasting and its cost is beyond calculation. It has received the careful consideration of the world's greatest economist, and is a problem whose solution requires far greater intellect than mine. Nevertheless, it vitally affects the interests of everyone of us here tonight, for it contains possibilities which one shudders to contemplate, with the tide of Bolshevism rolling westward, and other forces at work to mold our civilization into new and different and untried forms. Here and now are demanded more than ever before that "moral and intellectual clearness of the individual citizen" referred to by Huxley; now, more than at any period in our history do we appreciate the worth of that poise and stability which are provided and acquired by education; and now do we feel more fully than ever the importance of extending education to those of all classes who are in any way responsible for the industrial turmoil existing and impending.

It has always seemed to me that labor troubles must, in large measure, result from a failure on the part of the protagonists to understand each other's respective situations and motives; from a lack of comprehension of the simple elements of economics on the part of the masses, and the failure on the part of the employer to explain how and why conditions have arisen which have made necessary or inadvisable a readjustment of any accepted or demanded situation. In other words, through lack of education. And here, it seems to me, is an opportunity and a duty for the engineer. He occupies a peculiar relation to the capitalist and the laborer. He is customarily one of the employed; he is, on the other hand, the adviser and trusted representative of capital. He comes into frequent and close contact with the laborer, and is in a position to understand his difficulties, to win his friendship and confidence, and to impart advice and information which would go far to explain the difficulties of any given situation. He is a sort of middle man, who might easily acquire such influence with those above and below him as to be of very great aid in time of industrial crises. If this be indeed true, then it must follow that in not exercising this privilege, in not performing this service, he is not meeting fully his responsibilities as an engineer and a citizen. As the boys would say: he is not strictly "on his job."

Let us consider for a moment the situation in the average mining camp. A few hundred or few thousand miners are employed. Here they come, muckers, mule skinners, trammers, nippers, timbermen, machine men, track layers, powder monkeys, station tenders, pipe men, carpenters, electricians, shift bosses, blacksmiths, and helpers, of different nationalities and varying degrees of intelligence and education. They

are checked in and checked off by the time keeper; except in case of accident they spend their alloted time on the job and disperse without receiving as much personal attention as the mules underground. When not at work, they spend their time idling around saloons or other shady resorts where they not only learn nothing to their advantage, but spend their substance and sap the foundations of their health and strength, mentally, morally, and physically. Under such conditions they afford fertile and receptive soil for the seeds sown by the demagogic agitator. They attend open or secret meetings of the union and are constantly taught the program of violence and disrespect for law and order. In those camps where club houses are provided and reading matter and forms of amusement furnished, they are seldom visited and cultivated by anyone connected with the mine management. The men are still left to their own devices, and no advantage is taken of the opportunity to gain the friendship and confidence of those who are approachable, to aid those who are worthy and in need of some sort of encouragement or assistance, or to educate those eager for knowledge.

In recent years, it is true, many mining companies have arranged for moving picture shows two or three times each week; in some states like Nevada, the State educational institutions, such as the College of Mines, have of late years conducted night schools for instruction in scientific and technical subjects; and the Federal Bureau of Mines has sent its car around and taught the men the principles and methods of safety first. In all of these matters, the mining engineers have taken a part and shown sympathetic interest; but it seems to me we have fallen far short of the full measure of our duty and our opportunity. We have failed on the social and humanitarian side; we have done little to counteract the deliberate spread of socialistic and bolshevistic doctrines; we have permitted the raising of a crop of noxious weeds on soil which might well have yielded the fruits of thrift, industry, loyalty and patriotism.

With the coming of prohibition and the closing of the saloons, those old-time haunts of the miner, we find the men increasingly in need of comfortable recreation quarters, and in better condition to be interested in opportunities for entertainment which shall be at the same time instructive and uplifting. There are many forms of such entertainment, and many methods by which such instruction may be given without the appearance of officiousness or pedantry. I have never yet visited a mining camp where there were not some men of ideas, of travel, of wide experience and observation, of talent in some form of entertaining, where there are not frequent visitors who could be pressed into service for the benefit of the general cause of education and good fellowship. And there are ways and means by which such service could be organized and carried forward. There are national organizations and societies; there are State institutions; there are our own Local Sections; and there are the mining companies themselves which would quickly appreciate the value of such work among their men. It is probable that our Committee on Industrial Organization, with its sub-committee on Education, may be already at work along these lines. But we should not leave it entirely to small committees. It is work for every one of us, to be performed daily and perpetually, wherever we may be. It is not only a moral duty, but is one of the best expedients for making sure of permanent tenure of our positions and the salaries thereto attached. How many of our engineers are now enjoying princely honorariums in Russia? None.

How many are at work in Mexico? Very few. What is the fundamental reason in both countries? Illiteracy. How many engineers will be thrown out of employment if bolshevism carries out its declared program in the United States? Untold thousands. Is it not then, in the most literal sense, our job to protect our jobs by dissolving and dispersing the clouds of prejudice and ignorance which threaten the existence of all kinds of employment and the destruction of all industry? Yea, verily.

Nor is the laboring man the only one who needs educating. We need it ourselves; and so do Congress and Capitalists, managers, and the general public. The engineer's own education is too often defective in economics and politics, and he suffers thereby. He is wounded in his most sensitive parts by bad mining laws, by wrong principles of taxation, by ill-advised governmental regulation. In the conduct of all these matters he often has a keen sense of defective functioning, but is not sure of the remedy, nor skillful and earnest in urging its adoption; and in his perplexity often decides that he is not the doctor nor the plumber to stop up that particular leak! And when the trouble has grown irritating and chronic and no one provides a cure he is apt to become cynical and to blame society and the government for a situation which he himself should have helped to alleviate.

Now, Brother Engineers, let us have more confidence in the essential fair-mindedness of our fellows; let us believe in the future of our country; let us feel some responsibility for the condition of society; let us individually and through our Institute and kindred organizations cultivate simplicity of analysis, clearness of thought, expression in words of one syllable, and let us seek means by which we may increase our moral efficiency, improve the relations between the citizen and the government, between the employer and the employed; and so add to the sum of human happiness. The task may appear great but there are many workers and there will be an abundant reward in the resultant and well justified consciousness of service rendered combined with a swelling sense of pride of profession, pride of race, and pride of country.

EXCURSION TO FEDERAL SHIPBUILDING PLANT

On Thursday, February 20, about 240 attended the excursion to the Federal Shipbuilding Plant, at Newark, N. J., where through the courtesy of the manager, Mr. Robert McGregor, and his assistant, Mr. W. A. Bush, the entire plant and the ships under construction were open to the visitors. An unusual feature of the trip, worthy of note at the beginning, was the manner in which the party was guided about the plant. Thirty or more guides were provided. Each of whom wore a large badge bearing a number and was provided with ten pasteboard tags, bearing the same number as that on his badge, which were given to the guests. These constituted his party, for which he was responsible during the trip. These tags were given out when the party went through the gate and the guides kept their parties intact and the specified number of minutes behind the party ahead. This not only prevented crowding, but prevented the bunching of visitors around some prominent member of the Institute or some fair feminine attraction, and gave a party of suitable size so that the guide could give descriptions and explanations so that all could hear. A specified route for the visitors had been laid out and it had been arranged that in all of the departments through which they were taken,

there would be few or no obstructions. Great care was taken to prevent accidents and, thanks to the foresight of the management, none occurred, although it was an extremely busy place.

There are twelve ways at the plant with a ship being built on each, which were in various stages of construction, from one with an uncompleted keel to another that will be launched in about a week. Three recently launched ships were floating in the basin, almost completed, and one completed ship left the plant and started out to sea as the visitors' train arrived.

The Federal Shipbuilding Co. was formed in July, 1917, by the United States Steel Corporation, in order to assist in the great shipbuilding program being carried out by the United States Shipping Board for war purposes. The plant is situated on the west bank of the Hackensack River, and comprises about 185 acres of land, originally marsh, practically covered by water at high tide. About 750,000 cu. yd. of fill was obtained by the excavation of the wet basin and dredging of the Hackensack River and a final top fill of cinders was applied. The first pile was driven on Aug. 6, 1917, and the construction work was prosecuted in a most energetic manner, despite the severe winter and other difficulties.

All of the facilities and organization of the United States Steel Corporation were generously placed at the service of the Federal Shipbuilding Co., which accounts for the remarkable and substantial progress made. The plant is entirely self-contained, having twelve ways, and a fitting-out basin capable of accommodating eight steamers at one time, beside the necessary workshops for carrying out every detail of manufacture required in ship construction. Special attention has been paid to welfare work and safety appliances as carried out in the other subsidiary companies of the Corporation.

The first keel was laid in November, 1917, and up to the present time nine boats have been launched and five delivered. These steamers are 410 ft. over all, 55 ft. beam, with a deep draft of 27 ft., carrying 9600 tons of cargo, and will make a speed of 11½ knots loaded. Satisfactory results have been given by all the vessels delivered, and the boats are a fine type of the modern economical cargo carrier.

In order to make the greatest possible progress under war conditions. about 60 per cent. of the first thirty steamers was fabricated by the American Bridge Co. and sent into the plant all ready for erection, the remaining portions consisting of the two ends were fabricated in the plant.

During the early part of 1918, extensive preparations were made for carrying out experimental electric welding with the view of building steamers without rivets. This work was under the charge of the Emergency Fleet Corporation's Experimental Section, but on the signing of the armistice, operations were suddenly stopped, and the equipment is now dismantled.

After the plant had been inspected, the party was conducted to the old office building, now used as a restaurant, where a very elaborate luncheon, comprising soup, celery, olives, roast chicken, candied sweet potatoes, peas, salad, sandwiches, desert, and coffee, was served. After the luncheon, two very brief and interesting speeches were made by Mr. Bush of the plant and Mr. Henry of the excursion committee, and an enthusiastically unanimous vote of thanks was given to the manage-

ment of the plant for their most generous courtesies and a most interesting trip.

MEMORIAL SERVICE TO DR. ROSSITER W. RAYMOND

All technical sessions Monday afternoon were brought to an end in time for the members to gather in the Auditorium as the Institute paid its tribute to Dr. Rossiter W. Raymond. In opening this meeting, President Jennings said:

We have gathered here to render our tribute of honor and affection to the memory of one who was for 47 years the guiding genius of this Institute. One of its founders, and at that early day one of the foremost in his profession, he saw it grow from infancy to the great body it is to-day. At the beginning, as now, its membership comprised the leaders in geology, mining, metallurgy, and technical education. Because so many were qualified to lead, and because ambition is an essential qualification for leadership, the most momentous of the problems coming before them for solution was the selection of the one to whom they could confide the care and direction of the institution which was to record their proceedings and to stand as an enduring monument of their accomplishments. Their decision would determine whether the members of this group of leaders were to be coöperators or competitors—associates with a common purpose or rivals for individual advancement.

The selection of Rossiter Worthington Raymond for Vice-president, President, and finally Secretary; his retention in that office for 27 successive years; his elevation to the office of Secretary Emeritus and to Honorary Membership, constitute a testimonial greater than any honor that we can offer to his memory. In holding these exercises to-day, we simply voice our confirmation of the wisdom displayed by his colleagues in placing in his hands the guidance of their enterprise.

The Resolutions passed by the Directors, and printed elsewhere in this Bulletin, were then read. Afterward, Dr. Henry S. Drinker, president of Lehigh University and one of the two survivors of the twenty-two who attended the first session of the Institute, was then introduced.

ADDRESS OF PRESIDENT DRINKER

A friend, whom we loved, has gone from among us. He was a man who by his genius dominated any assembly in which he stood. He was a teacher of teachers, a leader in all the many lines in which his energetic able personality led him.

Of his eminence as an engineer, and of his ability, learning, and surpassing power in argument and presentation as an expert and as a lawyer, I will not speak—the tributes paid him by Mr. Rickard and Mr. Ingalls are so well studied that they should stand as the record of our friend's professional reputation. He was a wonderful man in the absolute absence of pretense in all that he said and did. If Raymond said it you could rely it was so—and his mind was so encyclopedic—his learning so vast, that association with him was an education, intensive and broad.

It was my privilege to know him for a life-time. We were associated with the founding of our Institute at Wilkes-Barre in May, 1871. I was then a young fellow just stepping out into practice from college training under Rothwell in the Lehigh School of Mines, and Raymond and Roth-

well, Coxe and Coryell, the men who organized the first coming together of the Institute, were men in the leadership of the profession, earnest, enthusiastic—early exponents of the profession they dignified and in fact introduced into this country.

From the beginning, Dr. Raymond's trained mind, inexhaustible energy, and wonderful aptitude of expression enhanced by his personal charm of manner, meant everything in the early setting and development of our Institute, which has grown into such a power in the engineering progress of our land.

We all pay tribute to Dr. Raymond's recognized ability and power of leadership—but there are today but few of us left who can personally turn and look back over a half century of actual association with him, a precious privilege filled with memories of a man of whom it may well be said he was typical of "Whatsoever things are true, whatsoever things are honest, whatsoever things are just, whatsoever things are pure, whatsoever things are lovely, whatsoever things are of good report," for he was of virtue—and we may well, in thinking of him, think of these things. Dr. Raymond was generous in his encouragement and aid to younger men. I can personally, with all my heart, echo the words of Ingalls in his recent splendid tribute to Raymond where he speaks of having in his early association with the *Engineering and Mining Journal* looked on Raymond as "a guide, philosopher, and friend," trite words—but never more aptly or better or more truthfully applied.

Dr. Raymond's history has been recorded, and his engineering record has been and is being given by men far better fitted than I to do technical justice to so large a subject. It is for me as one of Raymond's many friends and admirers, one of his old friends, yet speaking from the standpoint of one younger than he and ever looking up to him as a leader and teacher, to pay tribute to his personal qualities that so endeared him to all who were privileged to know him. I owe a great personal debt to him for encouragement and aid to me as a young man, and I am moved to speak of it only as an instance of what was common to so many, for he was ever ready with counsel and cheering words of uplift and practical suggestion to the younger men who came under his observation, and in this he typified in person, what our Institute has done as an association. Founded as it was by men of large heart and human sympathy, such as Raymond and Eckley B. Coxe, the Institute, particularly in its younger days when our membership was small, and the friendships engendered among members were intimate and common to all, did, and indeed has ever continued to do, a great work in giving to young engineers who came into its fold opportunity for betterment by association with older and eminent men, with an opening for the publication and discussion of their engineering experiences, and theories. In the development of this practice, and as the able Editor for many years of our Transactions, Dr. Raymond ever showed his kindly sympathetic helpful nature, and the men, and their number is legion, whom he so aided, pay tribute today to his memory with loving gratitude and appreciation.

He was a wonderful man in his faculty of doing so well so many different things.

Did his record rest only on his professional work as mining engineer, metallurgist and mining lawyer, his friends might be content, but he was not content with this. Dr. Hillis has told us in his beautiful tribute

to our friend, of Dr. Raymond's leadership in religious work in Plymouth Church, and how after Mr. Beecher's death Dr. Raymond was asked to retire from his engineering and editorial work and take up the pastorate of Plymouth Church (and how beautifully his reply reflects Dr. Raymond in his sincerity, good judgment, and never-failing humor)—Dr. Raymond said, that the Providence of God, through his fathers, had lent him certain gifts, and by His providence guided him into an appointed path, and now that his life journey had been two-thirds fulfilled, he did not believe that the Lord was going to return to the beginning of that path, and reverse Himself, and he would, therefore, follow the way appointed to the end of the road.

And in Plymouth Church and the friendships he made and cherished there, we can see how, while laboring for the good of his fellow-men, and for their souls' good, he yet rested from his professional work, and took pleasure and solace in his touch with the Church and Sunday School in which his heart delighted.

His addresses in the Church, of which many have been published, show a vivid and ever fresh and inspiring flood of wise helpful admonition and teaching—and his annual Christmas stories to the Sunday School children—fifty in all, ending with the one given on Sunday December 29th, only two days before his death on December 31st, are a unique and beautiful illustration of the faculty he possessed of using his great gifts for the young. The fiftieth and last of his Sunday School addresses is as vivid in interest as its predecessors, among which those who read them can never forget the delicious talks chronicling the woodchuck who inhabited the Doctor's garden at Washington, Connecticut, and who is introduced with the words "At our place in the country, where we spend five or six months of the year, we have among other fascinating attractions, a woodchuck of our own. That is nothing very remarkable. The whole region is full of woodchucks, and the difficulty is *not* to have one.* * * Our Garden is not far from his hole on the lawn, yet he never comes into the garden—for which reason we call him Maud, after the lady in Tennyson's poem. That lady did come into the garden; but then she was invited. If the gentleman had sung to her "Don't come into the garden, Maud," or even if he had never mentioned the garden, I am sure she would have stayed away politely, just as our Maud does,"—and then the address goes on with Raymond's never ending sense of humor, deliciously emphasizing the wise words on current events and international politics that are voiced by the woodchuck in his conference with his host.

As Ingalls has well said, Dr. Raymond was one of the most remarkable cases of versatility that our country has ever seen—sailor, soldier, engineer, lawyer, orator, editor, novelist, story-teller, poet, Biblical critic, theologian, teacher, chess-player—he was superior in each capacity. What he did he always did well.

In his writings and poems his ever-present sense of humor shone out—and yet always there was an adumbration of wise reflection or suggestion—often a direct emphasis of advice on current questions of the day. In his wonderful story of "The Man in the Moon," published over forty years ago, and doubtless reflecting some of his own personal experiences as an officer in the Civil War, Dr. Raymond recorded in his inimitable way what today may well be read as a prophetic utterance

on the folly and the wickedness of the world war, in his account of the way that the opposing soldiers in the ranks came together on Christmas Day—and how a sentiment in favor of peace spread from the ranks to the peoples concerned until the Generals in charge of the war, and the Governing authorities of the countries concerned, awakened to the folly of the contention in which they had been striving and came together in a peaceful solution.

The story is an immortal one, and those of you who have not read it, have a great treat in store when you find it. "The Man in the Moon —A War Story."

Dr. Raymond's home-life was ideally beautiful and loving. On Christmas Day just passed this little poem—so characteristic of him, and so expressive of the love he bore Mrs. Raymond, accompanied his gift to her of a bond:

"Tis strange, Oh Lady! fair and fond
Of me (as likewise I of you)
That there should be another bond
Between us two!

"You do not need this thing to make
Your life more full of hope and rest;
And yet sometimes you well might take
More interest!

"And there is nothing better serves
For weary hearts and hands to droop on
And stimulate exhausted nerves
Than a good coupon."

Dr. Raymond suffered a great sorrow in the loss of the son of whom he was so justly proud, a loss that he bore with a man's fortitude, and in which he was upheld by the faith and hope that his life so strikingly exemplified. That he should have been first taken, leaving here the wife to whom he devoted so many years of loving care is a part of that great mystery into which we cannot look, but she at least has the comfort of the memory of her knight as one "Without fear and without reproach" a Bayard among warriors—a Sir Percival among knights.

Dr. Raymond belonged to many societies and his abilities received due recognition in many honorary titles from societies, universities and colleges. Among them it was the pleasure and honor of Lehigh University to confer on Dr. Raymond in June, 1906, the first Doctorate of Laws ever granted by the Institution. When, in 1905, I was asked by my fellow-alumni of Lehigh to lay aside my professional work and take on the responsibility of the Presidency of Lehigh University, it was to Dr. Raymond I went for advice on my course. He urged me to take it up and during the years since then I have reason to be grateful for his steady counsel and support, and his visits to speak to our student body have ever been welcome and uplifting.

He and our honored Dr. Drown and I had a close and common bond in the association we all three had with Lehigh, and I know of no words more fittingly applicable to Dr. Raymond than those he spoke of Dr. Drown at the time we laid the foundation of Drown Memorial Hall on

our Lehigh Campus. Dr. Raymond said: "How well I remember that sunny afternoon at Philadelphia, when, in the sacred stillness of 'God's Acre,' ringed with the noisy life of the metropolis, we buried in flowers and evergreens the body of our beloved friend, while, overhead branches, like these, waved their solemn murmurous benediction, and all around us white fingers pointed upward, mutely saying, 'He is not here; he is risen!'—and in our ears sounded that deep, dear message of the Spirit, chanting how the blessed dead rest from their labors, while their works do follow them!

"Methinks we do not always perceive the full meaning of that message. Too often we interpret it as saying, 'They depart; they cease from their labors; and the work they have done takes their place, as their only representation on earth, as all that is now left of their fruitful power.' Surely, this is not all. To rest is not to cease; to follow is not to remain behind forever separated from the leader, but rather to abide with the leader, though he be on the march.

"Our human experience is not without interpreting analogies. We know what it is to rest from our labors for a few happy summer weeks, laying upon other shoulders the daily burden and upon other hearts the daily anxiety, yet still in forest solitudes or up shining summits or by the boundless sea, carrying with us in a higher mood our work—weighing it more accurately, because we are not too tired; seeing it more clearly, because we are out of the dust of it; realizing its proportions and purpose, because distance gives us a perspective view; tasting its full sweetness, because its bitter cloudy precipitate has had time to settle; and renewing our high ambitions for it as we renew our strength for it. We rest from our labors, but our work goes with us, inseparably—only now we bear it, not as weight, but as wings.

"So, it seems to me, we are to think of our absent dead; they rest, but do not cease; they go on, and their work goes on with them. Indeed, the interpretation is yet deeper. To my ears, the Spirit says, 'Blessed are they who have labored so earnestly as to deserve the rest of a higher sphere of labor, and who have left behind them works which deserve to follow them, and to receive, even in that higher sphere, their continued remembrance and interest.'"

How more fittingly can I close this tribute to the memory of our beloved friend than by these his own words, spoken of a friend dear to him, and honored by us all—words that today we may cite as a requiem and fitting thought of Rossiter W. Raymond himself, loved by us, whose name will go down in the annals of our Institute as that of a super-man of many parts to whom we owe much.

ADDRESS OF T. A. RICKARD

"Brethren"—it was thus that he addressed us on an occasion that many of you will remember: in 1893, at Chicago, at the closing session of the International Engineering Congress. Other men, representing other nations, had spoken—some of them in poor English—before he was called upon to reply for the arts of mining and metallurgy in America. When he said "Brethren," the audience was startled into lively attention, which was maintained throughout his speech; for then, as always, he knew how to reach the minds of men, and their hearts too. I remember his saying that those present had taken part in numerous scientific

discussions; that they had evolved new ideas and had discovered new principles, but that they had done something much better: they had "discovered one another." So saying he put his finger on the distinctive feature of all such conventions. His mode of salutation also reminded those of us who were his personal friends that he was an evangelist as well as an engineer, and that he could instruct a bible-class in Job or St. Paul with the same power of exposition as he could deliver a lay sermon on mining or metallurgy. Indeed Rossiter Raymond was a deeply religious man, and no sympathetic understanding of his extraordinarily versatile character is possible without appreciating this fact. He was not only a prominent member of Plymouth Church, Brooklyn; he was superintendent of the Sunday-school for 25 years, he led in prayer-meeting and in bible-class, he interpreted the Old Testament during the period when the so-called higher criticism was undermining the faith of the churches, and he aided Henry Ward Beecher in steering his congregation through the storm of biblical exegesis that crossed the Atlantic forty years ago. The eminence that he attained as a religious teacher is measurable by the fact that when Beecher died the trustees asked him "to give up his work as editor, lawyer, and mining engineer, and take the pastorate of Plymouth Church," as recorded by the Rev. Dr. Dwight Hillis. He declined the honor, thinking it better "to give his life and strength to the vocation of an interpreter, chronicler, guide, and assistant to engineers, rather than to that of a creative and constructive leader." I quote the words he himself used on the occasion of the dinner celebrating his 70th birthday.

Not many in the mining profession knew this phase of his character, although during his journeys through the West he would occasionally take the pulpit in some mining community and surprise a congregation that knew him only as the most distinguished of the experts engaged during the previous week in an important apex litigation. I have spoken of the part he played in the history of Plymouth Church, but his deeply religious nature was never so brought home to me as when his son Alfred died in 1901. He was a son of whom any father might feel proud; gifted and amiable, and on the threshold of a brilliant career. When he died Dr. Raymond proved, if it were necessary, the sincerity of his religious convictions, for his glad way of speaking of his departed son showed his confidence in a future reunion. I never saw a more convincing expression of the belief in immortality than in the attitude of Alfred Raymond's father and mother. It were improper for me therefore on this occasion to speak of the passing of our honored friend in a lugubrious strain. I shall speak of his life and career as an inspiring memory to be treasured as a heritage of our profession; and in doing so, I shall abstain from flattery. To extol the honored dead with honeyed words is an impertinence. Rossiter Raymond's career was so rich in performance as to require none of the insincerities of conventional biography.

To the profession, Dr. Raymond's work as Secretary of the American Institute of Mining Engineers was the outstanding feature of his supremely useful life. When the Institute was founded, in 1871, he was elected vice-president, with the understanding that he would perform the duties of president, which David Thomas, by reason of his age, could not discharge. Thus from the beginning Raymond was the real president, and, on the resignation of Mr. Thomas, a few months later, he became president, in name as well as in fact; thereafter to be elected again and again, until an amendment to the rules, proposed by himself, provided

that no president could serve more than two years. Soon afterward, in 1884, he became Secretary, a post that he held for 28 years—until his retirement from active service in 1912. He was Secretary Emeritus until the end.

The duties of the Secretary included the editing of the Transactions. For this he was well prepared. He had been the writer of successive volumes of the "Mining Statistics West of the Rocky Mountains;" he had been editor of the "*American Journal of Mining*" for one year, in 1867, and for the seven following years the editor of its successor, the "*Engineering and Mining Journal*," of which he continued to be associate editor with Richard P. Rothwell until they had a friendly disagreement over the "silver question" in 1893, after which he withdrew from editorial responsibility, becoming a "special contributor," in which capacity he assisted the editors that succeeded Rothwell. Thus he took a notable part in the development of technical journalism in this country; but I regard his share in the early editing of the JOURNAL as important chiefly because it was a training for his life-work, that of Secretary of the Institute. It is noteworthy that as the owner of the JOURNAL in its early days he found the work of writing and editing far more to his taste than the management, for in financial affairs he was too kindly to be a shrewd business-man.

As Secretary of the Institute he performed divers duties; he invited written contributions and revised them before publication; he organized the meetings; he was the administrator. In course of time his ebullient personality so dominated the Institute that he was allowed a free hand to do as he thought fit. Presidents came and went; although nominally Secretary, he exercised complete control. The personnel of the board of management, or "council," of the Institute changed from year to year, but Dr. Raymond managed its affairs, practically without let or hindrance. The Institute became identified with him. For a period longer than a generation he was the mainspring of the activities of the Institute, its presiding genius, its chief spokesman. Those who participated in the meetings of ten or twenty years ago will retain a vivid impression of the way in which Dr. Raymond stamped his individuality on the organization. Courteous and friendly to all, resourceful and tactful in steering the discussions, witty and eloquent whenever he rose to his feet, he was the managing director of the proceedings; he gave point and distinction to them; he infused them with his keen enthusiasm; he lighted them with the brilliance of his mind. His versatility was unlimited. All knowledge was his patrimony and nothing human was alien to his understanding. Whatever the subject of a paper, he could add something to it; nay more, on many occasions when some new phase of geology or engineering was presented for discussion, he would rise to supplement the speaker's remarks and show himself so well informed on the subject as to eclipse the specialist. He did this not unkindly, but out of super-abundance of knowledge and sheer exuberance of spirit. On the other hand, no member engaged in preparing a paper for the Transactions failed to obtain his whole-hearted assistance in collecting the necessary data or in hunting for the needed references. When the member's manuscript arrived, the Doctor went through it with painstaking care. Before the use of the typewriting machine came into vogue, and even after, he would send letters in long-hand of as much as ten pages, explaining or suggesting improvements in the text. As a beneficiary of his conscientious industry,

I can testify to the instruction in the art of writing that he gave to those who contributed to the Transactions. He was a delightful helper and a stimulating teacher. If any criticism is to be made, I venture to suggest that he over-edited; that is to say, the writings of the inexperienced were so much revised as to be practically re-written by him. He would take the half-baked production of a semi-literate engineer and subject it to the warmth of his intellectual combustion until it emerged a wholesome biscuit. I recall a valuable metallurgical paper, written by a professor now recognized as an authority, that was so full of German idioms that Dr. Raymond had to re-write it. Shortly before the Colorado meeting of 1896 I persuaded a Cornish mining engineer to contribute a paper on the lode-structure of Cripple Creek. He was a keen observer, but a poor writer; when the paper arrived it was quite unsuitable for publication. Dr. Raymond showed it to me and said, "What am I to do with this?" I replied, "Don't accept it." "No," said he, "that would not be fair; we asked him to write it." "Yes," I said, "but I am responsible for asking him; let me lick it into shape." "No," he insisted, "that is my job, I'll see what I can do with it." He did, and he did it so thoroughly that my Cousin Jack friend obtained credit for an informing and well-written contribution to the Transactions. The result of such revision was to lessen the value of the paper as scientific evidence. The authenticity of the testimony, it seems to me, suffered by being given through the mouth of a skilled advocate. On the other hand, this overplus of editorial labor gave the Transactions a level of style that no other technical society could claim either then or since. All technical writing in the English language has felt, and long will continue to feel, the inspiration to excellence that he gave while editor of the reference library that we call the Transactions of the American Institute of Mining Engineers.

He left an enduring mark on the jurisprudence of mining. A keen observer and a clear expositor, he achieved distinction as an expert witness in the litigation arising from attempts to apply the law of the apex, a subject on which he wrote a series of essays that exercised a strong influence on the interpretation given by the highest courts to that Congressional statute. In the first big case in which he took part, the famous Eureka-Richmond lawsuit, he gave the term 'lode' a definition that not only swayed the decision in that controversy, but influenced all later mining litigation. On one occasion he was invited to address the United States Supreme Court on a point of mining law, and his exposition is said to have been accepted by the Court in its subsequent opinion. At that time he had not qualified as a lawyer, but in 1898 he was admitted to practise in both the State and the Federal courts. Five years later he was appointed lecturer on mining law at Columbia University.

As an expert witness, he was, as he said of Clarence King, approvingly, "an honest partisan." He used the gift of exposition with great effect when addressing the jury, under cover of giving evidence. I recall the explanation of the formation of mineral veins with which he began his testimony in the Montana-St. Louis case. Fortunate was the jury that had the opportunity of listening to such a fascinating lecturer. He was not only an able witness in chief and extremely dexterous in circumventing cross-examination, but he was a great general. He was quick to recognize the important features of a case and skilful in marshalling his forces to the discomfiture of the enemy. In forensic duels he displayed

characteristic wit and versatility. This legal practice was a source of honor and profit to him, but I venture to say that he helped geology more in other ways.

In 1868, when only 28 years of age, he was appointed U. S. Commissioner of Mining Statistics, and in that capacity he visited the mining districts of the West, which was then at the beginning of an era of widespread exploration. He was quick to appreciate the economic value of geology and to utilize the opportunities for study afforded by his official travels. In 1870, he was appointed lecturer on economic geology at Lafayette College, which appointment he held for twelve years.

When he became Secretary of the Institute he transferred his keen interest in economic geology to the Transactions. As Secretary, he persuaded the engineers to record observations made underground and at the same time he induced the officers of the Geological Survey to present their scientific inductions to the Transactions in a form that rendered them attractive to the mining profession. Thus he brought the official geologist into touch with the mine-manager and consulting engineer, greatly to the advantage of all. He also did much to diminish the self-sufficiency of the Survey and to lessen the shyness of the so-called practical man. By his understanding of geology, his knowledge of Western mining conditions, and the zest with which he pursued the application of geology to mining, he aided greatly in exciting intelligent interest in the genesis of ore deposits. The Posepny volume proves that; so does the volume dedicated to the memory of his friend Emmons. In 1893, he translated Posepny's treatise from the German into his own vigorous English, and organized a discussion that enhanced the value of the original paper. By means of another treatise, by Van Hise, presented to the Institute seven years later, in 1900, he gave a fresh impetus to the study of ore deposits, the general result being to make the mining geologists of this country the leaders in a branch of study in which European scientists had theretofore held pre-eminence.

On his skill as a writer it is pleasant to dwell. He wrote out of the fulness of a rich mind, an alert imagination, and an abundant vocabulary, aided by the knowledge of several modern languages. He knew not only how to select *le mot juste*, but also how to weave words into ingenious phrases and to construct balanced sentences, following each other in logical order within well-proportioned paragraphs. He liked to number his paragraphs, in order to emphasize successive points at issue. He wrote with pen or pencil, usually the former, because it is less rigid and therefore less fatiguing to the fingers. He did not like to dictate anything except ordinary correspondence, but he could dictate a long article or legal testimony, punctuation included, with remarkable clearness and continuity. He wrote easily, with all the joy of the practised hand and the disciplined brain. He twitted one of his contributors with having "an inveterate fluent profuseness of speech" and the happy victim protested that the phrase exactly fitted *him*, not the lesser writer. He was fluent and profuse, but not to redundance or verbosity; on the contrary, his style was marked by force and consecutiveness, and, not infrequently, by those "saber thrusts of Saxon speech" that are the delight of the critical.

His literary ability was partly inherited from his father, Robert Raikes Raymond, who was editor successively of the *Free Democrat* and the *Evening Chronicle*, at Syracuse, New York, from 1852 to 1854,

and later Professor of English in the Brooklyn Polytechnic Institute and Principal of the Boston School of Oratory. It is also a safe surmise that Rossiter Raymond owed much of his fine feeling for the language of Shakespeare to his daily draughts from that well of English undefiled, the King James version of the Bible. There is no better schooling in our language than familiarity with The Book. A third aid to the cultivation of a good prose style was his frequent exercise in versification. The expression of simple ideas in verse by means of short words is excellent training for the effective construction of logical sentences in prose; moreover, the sense of rhythm incites assonance. On his return from life at the German universities, he brought with him many old folk-songs and student-songs, some of which he adapted to Sunday-school use. Thousands of children sang his hymns with delight because he knew how to present pretty thoughts in simple guise. That he could write serious poetry we know; for example, the lines to the Grand Canyon engraved on the silver tray that formed part of the gift presented to him on his 70th birthday. He wrote merry rhymes for our Institute meetings and for other occasions of a similar kind, making good-natured fun for himself and his friends. This playing with words in rhyme and rhythm gave him facility of expression in the more serious business of prose, and also in public speaking.

He was a delightful speaker. Our profession has never had a more eloquent spokesman. He seemed as little at a loss for ideas as for words; his enunciation was clear, he had a resonant voice, and his gestures were natural. Owing to his retentive memory and easy delivery, it was difficult to distinguish a speech that he had written from one that was extempore.

At any gathering he was individual—a distinguished figure. The wearing of a black silk cap and an old-fashioned way of trimming his beard gave him a striking appearance. Clear eyes wide apart, an aquiline nose, and a square chin indicated imagination, perception, and determination. His military training had taught him to stand upright. His pose was that of a captain of men. When he made a humorous hit he would tilt his head and smile, as if eager to share the fun with his audience. He never touched anything without giving it human interest. He found

> "Tongues in trees, books in the running brooks,
> Sermons in stones, and good in everything."

Rossiter Raymond exercised an immense influence in his day and generation—nay more, two generations felt the force of his personality. How he stimulated his religious co-workers has been recorded by the successors of Henry Ward Beecher. Both Lyman Abbott and Dwight Hillis have testified to the courage that he imparted to them during the troublous times of Plymouth Church. To the geologists who broke the trail for the scientific investigations of a later day he was a guide, philosopher, and friend. Such men as Clarence King, James D. Hague, and S. F. Emmons have recorded their gratitude for his support and advice. Among his engineering contemporaries were scores to whom he was an ever-ready source of information, a wise counselor, a cheery friend—for them he did many unselfish and kindly things. To those of us who were young when he was at his prime he was the very embodiment of

scientific attainments. We looked up to him as the exemplar of effective writing and polished speaking, the pattern of engineering culture, the leader in everything that concerned the welfare of our profession. As Secretary of the Institute we found him a lovable man, full of natural kindness and that helpfulness, without condescension, which the young appreciate so keenly when shown by a senior whom they admire. We—for I was one of them—found him an inspiring leader and a loyal friend. Loyalty—yes, that was one of his qualities. It got him into trouble more than once, for in friendship, as in apex litigation, he was unmistakably partisan. He stuck to his friends through thick and thin; he gave them the benefit of the doubt if they did wrong; he championed them when they were set upon. Lucky was the man on whose side he fought.

He was pre-eminently a publicist and an educator; he declined the pastorate of Plymouth Church to become the pastor of a bigger congregation; he resigned his professorship at Lafayette to be a teacher in a bigger school; he was the dean of the mining profession in the United States. For fifty years the force of his personality was felt among the men that were organizing and directing the mining industry of a continent; for fifty years he did not fail to write a Christmas story for the children of his Sunday-school; he was a friend to the old and to the young. Age could not wither him nor custom stale his infinite variety. He influenced those that today are influencing others; his spirit still moves among men. Blessed be his memory.

BRIEF BIOGRAPHY OF DR. RAYMOND

Rossiter Worthington Raymond, Ph.D., LL.D., mining engineer, metallurgist, lawyer and author, was born in Cincinnati, Ohio, April 27, 1840, son of Prof. Robert Raikes and Mary Ann (Pratt) Raymond; grandson of Eliakim and Mary (Carrington) Raymond, of New York City, and of Caleb and Sally (Walker) Pratt, of Providence, R. I.

He was of English descent, his earliest American ancestor on the paternal side, Richard Raymond, having emigrated from England to this country and settled at Salem, Mass., about 1632; while on his mother's side he was descended from well-known New England families. His great-grandfather, Nathaniel Raymond, was an officer in the Revolutionary army; and his grandfather, Caleb Pratt, served in the war of 1812.

His father (born 1817, died 1888), a native of New York City, was a graduate of Union College in 1839, editor of the Syracuse *Free Democrat* in 1852, and the *Evening Chronicle* in 1853–4, and afterward Professor of English in the Brooklyn Polytechnic Institute and Principal of the Boston School of Oratory. His mother (born 1818, died 1891) was a native of Providence, R. I. They were married at Columbus, Ohio, in 1839, and Rossiter W. was the eldest of a family of seven children, of whom four were sons.

He received his early education in the common schools of Syracuse, N. Y., and in 1857 entered the Brooklyn Polytechnic Institute, of which his uncle, Dr. John H. Raymond (afterward President of Vassar College), was then President, graduating from that institution, at the head of his class, in 1858. He spent the ensuing three years in professional study at the Royal Mining Academy, Freiberg, Saxony, and at the Heidelberg and Munich Universities.

Returning to the United States in August, 1861, he entered the Fed-

eral army and served as aide-de-camp, with the rank of captain, on the staff of Major-General J. C. Frémont, by whom, during his campaign in the Valley of Virginia, he was officially commended for gallant and meritorious conduct.

From 1864 to 1868, he engaged in practice as a consulting mining engineer and metallurgist in New York City; and in the latter year was appointed United States Commissioner of Mining Statistics, which position he held until 1876, issuing each year "Reports on the Mineral Resources of the United States West of the Rocky Mountains" (8 vols., Washington, 1869–76), several of which were republished in New York, with the titles of "American Mines and Mining," "The United States Mining Industry," "Mines, Mills and Furnaces," and "Silver and Gold." These reports contained descriptions of the geology, ore-deposits and mining enterprises of the United States public domain, discussions of metallurgical processes adapted to American conditions, and observations and criticisms concerning the practical operation of the United States mineral land laws of 1866 and subsequent years. In 1870, he was appointed lecturer on economic geology at Lafayette College, which chair he occupied until 1882, and for one year during that period gave the entire course on mining engineering.

In 1873, Dr. Raymond was appointed United States Commissioner to the Vienna International Exposition and as such delivered at Vienna addresses in the German language at the International Convention on Patent Law, and the International Meeting of Geologists; and an address in English at the meeting of the Iron and Steel Institute, in Liége, Belgium. From 1875 to 1895, he was associated, as consulting engineer, with the firm of Cooper, Hewitt & Co., owners of the New Jersey Steel & Iron Company, the Trenton Iron Company, the Durham and the Ringwood Iron Works, as well as numerous mines of iron ore and coal. As President of the Alliance Coal Company, and director of the Lehigh & Wilkesbarre Coal Company, as well as a personal friend of Franklin B. Gowen, he became acquainted with the inner history of the memorable campaign against the "Molly Maguires," and has since been known as a fearless opponent of all tyranny practised in the name of labor. His articles on "Labor and Law," "Labor and Liberty," etc, published in the *Engineering and Mining Journal* at the time of the Homestead riots, attracted wide attention and for these, as well as similarly frank discussions of the operations of the Western Federation of Miners in Montana, Idaho and Colorado, he received special denunciations and threats from the labor unions thus criticised. While connected with Cooper, Hewitt & Co., he also assisted Abram S. Hewitt in the management of Cooper Union and for many years directed the Saturday Evening Free Popular Lectures on Science, etc., which constituted the beginning of what has since become a vast lecture system in the city of New York.

From 1885 to 1889, he was one of the three New York State Commissioners of Electric Subways for the city of Brooklyn, and served as member and secretary of the Board, preparing its final report, which was generally regarded as the best statement of the problem of municipal engineering and policy involved in the distribution of electric conductors. At the close of his official term as Commissioner, he became consulting engineer to the New York and New Jersey Telephone Company, which position he retained for many years.

In 1898, Dr. Raymond was admitted to the bar of the Supreme Court

of New York State and of the Federal District and Circuit Courts, his practice being confined to cases involving either mining or patent law, in the former of which he was a leading authority. In 1903, he was lecturer on Mining Law at Columbia University, New York. He has also delivered numerous addresses at other colleges and universities, including Yale, Cornell, Pittsburgh, Lehigh, Lafayette, Union, California, the Worcester Polytechnic and the New York College of Physicians and Surgeons.

An original member of the American Institute of Mining Engineers, he served as its Vice-president in 1871, 1876 and 1877, President from 1872 to 1875, and Secretary from 1884 to 1911. In the latter capacity he edited 40 of the annual volumes of *Transactions*, to which he liberally contributed essays, especially pertaining to the United States mining laws, as well as other articles of importance.

In 1911, Dr. Raymond resigned his position as Secretary of the American Institute of Mining Engineers, of which he has been since that time Secretary Emeritus.

Dr. Raymond was the editor of the *American Journal of Mining* from 1867 to 1868, of the same periodical under the title *Engineering and Mining Journal* from 1868 to 1890, and thereafter was a special contributor to that journal. In 1884, he prepared for the United States Geological Survey an historical sketch of mining law which was subsequently translated into German and published in full by the *Journal Des Bergrechts*, the only periodical in the world devoted exclusively to the subject of mining jurisprudence, and for which he received high praise.

In addition to the official works previously mentioned he was the author of "Die Leibgarde" (1863), a German translation of "The Story of the Guard" by Mrs. Jessie Benton Fremont (1863) "The Children's Week" (1871); "Brave Hearts" (1873); "The Man in the Moon and Other People" (1874); "The Book of Job" (1878); ("The Merry-go-Round" (1880); "Camp and Cabin" (1880); "A Glossary of Mining and Metallurgical Terms" (1881); "Memorial of Alexander Mining Law" (1883–95); "Two Ghosts and Other Christmas Stories" (1887); "The Life of Peter Cooper" (1897); various technical works and papers on mining law, as well as numerous addresses and magazine articles, and contributions to several American dictionaries and encyclopedias.

In 1909, in collaboration with W. R. Ingalls, he contributed to the First Pan-American Scientific Congress, held at Santiago, Chile, a paper on "The Mineral Wealth of America," and at the Second Congress, which assembled at Washington, D. C., in 1915, he was represented by a paper entitled "The Value of Technical Societies to Mining Engineers." Legislation" was delivered in 1909 before a joint meeting of the four national engineering societies.

In 1916, Dr. Raymond published a volume of poems, entitled "Christus Consolator and Other Poems." At the time of his death he was at work upon a history of the American Institute of Mining Engineers, which he hoped to finish this year.

In 1910 the 70th birthday of Dr. Raymond was celebrated by a dinner at which all branches of the engineering profession, the scientific and learned societies, and the prominent institutions of learning were represented. On this occasion the gold medal of the Institution of Mining and Metallurgy was awarded to Dr. Raymond "in recognition of eminent services and lifelong devotion to the science and practice of

mining and metallurgy and of his numerous and valuable contributions to technical literature."

In 1911, during the visit to Japan of members and guests of the American Institute of Mining Engineers, Dr. Raymond received from the Mikado the distinction of Chevalier of the Order of the Rising Sun, fourth class—the highest ever given to foreigners not of royal blood—"for eminent services to the mining industry of Japan." These services consisted in advice and assistance rendered in America to Japanese engineers, students and officials throughout a period of more than 25 years.

Dr. Raymond was an honorary member of the Society of Civil Engineers of France, the Iron and Steel Institute and the Institution of Mining and Metallurgy of Great Britain, the Mining Society of Nova Scotia and the Australasian Institute of Mining Engineers. He was a Fellow of the American Association for the Advancement of Science and the American Geographical Society, a member of the American Philosophical Society, the Brooklyn Institute of Arts and Sciences, the American Forestry Association and various other technical and scientific organizations both at home and abroad. He received the degree of Ph.D. from Lafayette College in 1868, and that of LL.D. from Lehigh University in 1906. On the latter occasion, speaking as an adopted alumnus of the University, he delivered to the graduating classes an address on "Professional Ethics" which has been widely quoted and approved.

In February, 1915, Dr. Raymond delivered the commemorative address on the 150th anniversary of the foundation of the University of Pittsburgh, and received from that Institution the honorary degree of LL.D.

He married in Brooklyn, N. Y., March 3, 1863, Sarah Mellen, daughter of William R. and Mary (Fiske) Dwight of that city. Of their five children two survived to adult years; Alfred (b. 1865, d. 1901), an architect and engineer of thorough training and great promise; and Elizabeth Dwight (b. 1868), since 1892 the wife of H. P. Bellinger of Syracuse, N. Y.

He died suddenly, of heart failure, at his home in Brooklyn, N. Y., on the evening of December 31, 1918, and was buried in Greenwood Cemetery.

MEMORIAL MEETING FOR THE MEN WHO DIED IN SERVICE

At the close of the afternoon joint session with the Canadian Mining Institute, a meeting was held in the auditorium in memory of the members of the Institute who died in the service of the United States and the Allies. At this meeting Capt. Percy E. Barbour, Acting Assistant Secretary of the Institute, said: We have received word of the death of twenty-three of our members in service. The fifteen named in the following list were mentioned (and biographical notices were read) at the memorial meeting held in Colorado last September: Lewis Newton Bailey, Lieut. Louis Baird, William Morley Cobeldick, Ralph Dougall, Lieut.-Col. Alfred Winter Evans, Lieut. Thomas C. Gorman, Lieut. William Hague, Capt. William T. Hall, Lieut. Bernhardt, Capt. John Duer Irving, Lieut. Edward H. Perry, Lieut. Frank Remington Pretyman, Capt. Fred B. Reese, Soren Ringlund, Lieut. George Roper, Jr.

Since September, we have heard of the deaths of Capt. John H. Ballamy, Lieut. Martin F. Bowles, Andrew Burt, Corp. Sheppard B.

Gordy, Serg. Herbert M. Harbach, Sidney A. Lang, Lieut. Norman L. Ohnsorg, Raymond W. Smyth. Captain Barbour read brief biographies of these members as their portraits were shown upon the screen. Then two buglers from the army post on Governor's Island sounded taps for their comrades.

MEETING OF THE BOARD OF DIRECTORS, JAN. 24, 1919

At the meeting of the Board of Directors the following resolution was passed:

"The members of the Board of Directors of the American Institute of Mining Engineers desire to place on record their appreciation of the very great generosity of one of their colleagues and a member of the Board, George D. Barron, expressed in his gift of $5000 to relieve the financial stringency caused by the unusual expenditures of the Institute for war work and the remission of dues of those members on active service."

By-Law XIII. was amended to make a slight change in District No. 5.

The report of the Auditing Committee was accepted.

Tellers were appointed to count the ballots on officers and on the proposed amendment.

The proposed budget for the year 1919 was presented.

The following resolution re Secretary Emeritus Rossiter W. Raymond, which had been prepared, by request, by Dr. A. R. Ledoux was then unanimously adopted.

"The Board of Directors of the American Institute of Mining Engineers would place upon its minutes its profound sense of loss and sorrow in the death of Rossiter Worthington Raymond, Ph. D., LL. D., Secretary Emeritus of the Institute. Both as one of its founders and as its Secretary for 27 years, his was the guiding spirit of the Institute for more than a generation.

"During the greater part of this long period, it might almost have been said that the Institute was Dr. Raymond—and Dr. Raymond the Institute. When with the progress of growth and development, great changes were introduced, Dr. Raymond acquiesced in these in spite of some misgivings, such as those with which a father might contemplate the emergence of his child from the careful supervision of the home; but as Secretary Emeritus for the past eight years, he was always ready with valuable advice and helpful suggestion.

"His presence at the annual meetings was an inspiration, which his rare ability as a speaker further enhanced. Among the most versatile of men of genius, among the most distinguished as a mining engineer; a scholar, editor and authority on mining law, yet to his personal friends he revealed a simplicity, a loyalty, and a steadfastness which held his intimates and bound them to him in spite of time and change.

"With his death there closes an epoch in the history of American mining and metallurgy. The Institute thereby loses one of its great leaders, but his example will live as an inspiration to those who survive, within its councils, and his name will be long an inspiration for many who knew him only through our transactions and by his other writings."

Mr. T. A. Rickard was appointed editor for the Raymond Memorial biographical volume.

Arthur S. Dwight was requested to complete the History of the A. I. M. E., begun by Dr. Raymond.

The Steel Treating Research Society and the American Steel Treaters' Society were invited to attend the technical sessions of the Chicago Meeting of the Institute.

There were elected twenty Members, eight Associates, and fourteen Junior Associates; one change of status from junior associate to associate was granted. Three members were reinstated, and the resignations of twenty-two members were accepted.

The time for payment of initiation fee for the first year's dues was extended to one candidate; and the dues of certain members on active duty with the Allied Army were suspended.

The sum of $250 was appropriated to the San Francisco Section, and the sum of $5000 was appropriated as the Institute's share of recataloguing the Library.

Robert W. Hunt was unanimously elected an honorary member.

Mr. W. G. Swart addressed the meeting.

LOCAL SECTION NEWS

COLUMBIA SECTION

J. C. HAAS, *Chairman* W. J. HALL, *Vice-chairman*
LYNDON K. ARMSTRONG, *Secretary-Treasurer*, 720 Peyton Bldg., Spokane, Wash.
W. H. LINNEY J. F. MCCARTHY

At a meeting of the members of Columbia Section, which was held in the Davenport hotel, Spokane, Wash., Jan. 31, 1919, at noon, there were present about twenty members and guests. The chairman being absent, Mr. Frederick Keffer presided.

The Secretary announced the personnel of the executive committee of the section, which is: J. C. Hass, Spokane, Chairman; W. J. Hall, Wallace, Ida., Vice-chairman; S. S. Fowler, Riondel, B. C., Past Chairman; L. K. Armstrong, Spokane, Secretary-Treasurer; R. M. Betts, Cornucopia, Oregon.

It was stated that the geological survey and report on Stevens Co., Wash., has been completed and will be printed soon. The geologic survey of Colville Indian reservation, by J. T. Pardee, U. S. G. S., has been published as Bulletin No. 677 and is available for distribution, The Miner's Almanac, Miners Circular No. 24, U. S. Bureau of Mines. is also available upon request.

There was considerable discussion on the program for meetings during the year. It was informally agreed that, if agreeable to Coeur d' Alene members, that one meeting should be held in that district, preferably at the time of the annual visit of Institute officials. It was also proposed to hold at least one open-air meeting in Spokane with suitable program.

The activities of other sections were noted with favorable comment. In this connection there was much general discussion on the subject of closer relations between the national engineering societies. It was agreed that coöperation was desirable and imperative if the greatest measure of value be realized from the profession. It was not the sense of the members, however, that complete amalgamation is desirable. This expression of local sentiment is to be presented to the Institute

at the Annual meeting, either by a member of Columbia Section or by mail. The plan for local coöperation and the work to be performed through numerous committees was heartily approved.

After endorsement of a legislative proposal to expend $150,000 on road construction between Spokane and the Canadian International boundary within the least feasible time, Mr. Sidney Norman was delegated to draft a resolution favoring such expenditure, copies to be sent to proper legislators at Olympia and to the Spokane Engineering and Technical Association for its endorsement.

Lieut. John Semple, E. M., just released from the Air Service, U. S. A., in which he had been instructor, gave a very interesting description of aeronautics.

Mr. H. J. Honeywell, city chemist, spoke briefly upon the work of his department and advocated the local organization of a section of the American Chemical Society.

L. K. ARMSTRONG, *Sec'y-Treas.*

THE DAY SCHOLARSHIP

The establishment of the Day Scholarship at the School of Mines of the University of Idaho during the past year is another interesting event in the life of the Columbia Section. The founder of the scholarship is Jerome J. Day, a member of the Institute, manager of the Northport Smelter, and one of the owners of the great Hercules mine at Wallace.

One scholarship is to be awarded annually, the successful candidate being chosen from the graduating class of the high schools of Shoshone Co., the great lead-silver producing county of Idaho. Each scholarship is tenable for four years and carries an annual income of $250. This means a yearly expenditure on Mr. Day's part of $1000, which in terms of an endowment bearing interest at 4 per cent. is the equivalent of $25,000. Examinations for the scholarship are to be held annually, and are to be non-competitive in character, interest in athletic sports and qualities of leadership being considered with high scholastic standing. The election is to be made by a committeee consisting of the Commissioner of Education, the President of the University, and the Dean of the School of Mines.

Mr. Day denies any philanthropic motives in the matter, simply stating that the operations with which he is connected are interested in stimulating the supply of young men thoroughly trained in mining and metallurgy.

NEW YORK SECTION

ALLEN H. ROGERS, *Chairman* FOREST RUTHERFORD, *Vice-chairman*
H. C. PARMELEE, *Vice-chairman and Treasurer,*
W. S. DICKSON, *Secretary,* 71 Broadway, New York, N. Y.
J. E. JOHNSON, JR. F. T. RUBIDGE S. H. BALL

A meeting of the New York Section of the American Institute of Mining Engineers was held at The Machinery Club, New York City, Wednesday evening, Jan. 22. Mr. Sidney J. Jennings was in the chair. After the service of the dinner, Mr. H. C. Parmelee, editor of Metallurgical and Chemical Engineering, delivered an interesting address on "Notes on a War Time Trip to Europe," which was illustrated with a number of lantern slides.

Later, methods of conducting the meetings of local sections were discussed. Mr. E. P. Mathewson said that it had been found that by reducing the number of papers from three to one greatly improved the meeting. Another successful plan was to have a person talk on some subject of interest, particularly something with which he had been connected himself, and have men who were interested in that line present and prepared to discuss the question.

Mr. Walter G. Swart stated that, in Duluth, one of the large department stores, which is centrally located, had set aside a luncheon room where between fifteen and twenty-five engineers meet and have luncheon every day.

Mr. H. C. Parmalee, when asked to tell of the Denver Technique Club said that the fundamental characteristic of the Technique Club is the individual responsibility of the members for the success of the meeting. At the May meeting each year the dates of the meetings for the following year are assigned to certain men, who are to arrange the program for these dates, and that ends the responsibility of the officers of the Club, so far as the programs for those meetings are concerned. It is left to each member to whom the assignment is made to put on what he wants. If he chooses to sidestep the technical feature and get a vaudeville performer and entertain the club, that is agreeable; or if he personally speaks about something with which he has had personal experience and can make interesting, that is acceptable; but after he is through the meeting is opened for discussion and you can bet there is some discussion.

SOUTHERN CALIFORNIA SECTION

RALPH ARNOLD, *Chairman* WILLIAM F. STAUNTON, *Vice-chairman*
ALVIN B. CARPENTER, *Secretary-Treasurer*, 530 Citizens National Bank Bldg., Los Angeles, Cal.

A. B. W. HODGES LESLIE C. MOTT
C. COLCOCK JONES JAMES W. NEILL

Members of the Section and guests assembled at the residence of Mr. M. Elsasser, on the evening of Jan. 27, for the regular winter meeting. The principal speaker of the evening was H. W. Morse, technical manager of the American Trona Corp., who gave a description of the occurrence and treatment of the Searles Lake salts deposit and the production of potash therefrom.

A great many interesting lantern slides showing the lake and the extensive plant of the company were shown, and the production of potash was described in detail. In the discussion that followed, further data on potash and the possibilities for its production in quantity was given by Baron der Ropp and others familiar with the subject.

The occurrence and recovery of potash from the saline lake beds of Nebraska was next given by Mr. Carlton R. Rose, who has been in charge of some of these properties. An interesting comparison of the products from these different localities was thus obtainable. The product at Trona is a chloride of potash and that of the Nebraska lakes is the sulphate.

The ability to compete with the foreign product for the American market, after conditions become normal in this country, will depend to a considerable extent on favorable railroad rates from these western points, though the Trona Company, with its immense plant and with the treat-

ment on the extensive scale that obtains there, and with the skill that it employs in advancing the refinements of practice, will doubtless hold its own in maintaining a large domestic supply.

The latter part of the program consisted of a talk by Mr. J. W. Neill, who described an interesting trip into the Peace River country of British Columbia. The possibilities of that section for placer gold and platinum he said were practically nil. The existence of extensive deposits of coal of excellent quality in that region was noted.

The program of the evening was concluded with a talk on Alaska by W. N. Cummings, who described briefly the coal fields near Seward, and the terminal facilities being installed by the Government at Anchorage. Refreshments were served at 11 o'clock and a pleasant hour of social intercourse concluded a successful meeting.

ALVIN B. CARPENTER, *Sec'y-Treas.*

AFFILIATED STUDENT SOCIETIES

SCIENTIFIC SOCIETY, COLORADO SCHOOL OF MINES

At the last monthly meeting of the Scientific Society the following officers were elected: W. A. Conley, president; G. V. Dunn, vice-president; R. R. Ireland, secretary-treasurer.

J. C. ROBERTS.

MISSOURI MINING ASSOCIATION

During the period of the S. A. T. C. at the University of Missouri, the Missouri Mining Association was inactive. However it has now been reorganized with the F. G. Rackett, president, and H. H. Hoppock, secretary-treasurer. The first meeting, held Jan. 24, was addressed by Major C. R. Forbes, who spoke on "Mining as Applied to Military Work."

G. H. COX.

PENN STATE MINING SOCIETY

The organization of the Penn State Mining Society was accomplished under adverse conditions; the Students Army Training Corps had interfered with the Society's following the programs of previous years. The first meeting, Oct. 19, 1918, was in the form of an informal gathering, at which time the Society was addressed by ex-Dean Crane, Dean Moore, and other members of the faculty. A lunch was served. At the meeting held on Dec. 13, 1918, the following officers were elected: J. N. Hedding, '19, president; J. B. Maginnis, '20, vice-president; D. E. Keller, '20, secretary-treasurer. Dean Moore made a few remarks on the aims and purposes of the Society. The first lecture of the school year was delivered Jan. 10, 1919, when Dean Moore gave an illustrated talk on "Australian and Indian Mining."

A meeting schedule for the near future, probably Feb. 28, will feature a lecture by H. B. Kirkpatrick, of the H. Koppers Co. on "The By-product Industry." The lecture will be illustrated with moving pictures.

D. EDWARD KELLER, *Sec'y-Treas.*

UNIVERSITY OF WISCONSIN MINING CLUB

The University of Wisconsin Mining Club has elected the following officers for the scholastic year ending June 30, 1919. President, Edwin O. Werber; vice-president, Don V. Slaker; secretary-treasurer, Warren W. Walters; chief mucker, Everett L. Grubb, assistant mucker, Otto A. Ray.

WARREN W. WALTERS, *Sec'y-Treas.*

THE MINING AND METALLURGICAL CLUB, UNIVERSITY OF TORONTO

The Mining and Metallurgical Club of the University of Toronto made a visit to the Brown Copper and Brass Rolling Mills on Dec. 13 for the purpose of looking over the plant. The whole club turned out along with two or three of the staff. A very instructive afternoon was spent viewing the various parts of the plant including the reclaiming, rolling and casting shops. On the evening of Dec. 20, the first dinner was held at the Walker House. Talks were given by R. E. Hore, the editor of the Canadian Mining Journal, Mr. MacGregor, a mining lawyer of Toronto, and Professor Guess of the Faculty.

All these activities are carried on by far fewer members than in normal times, due to the depletion of students in mining and metallurgy by the war. However, our numbers are increasing and although not yet nearly up to normal, the interest taken by those that are present more than makes up for the dearth of students.

H. M. SHEPARD, *Sec'y-Treas.*

WOMAN'S AUXILIARY

FOREIGN WAR RELIEF COMMITTEE

Chairman, MRS. JESSE SCOBEY

The Foreign War Relief Committee closed its dispensary fund during the past month with a contribution to the American Fund for French Wounded of $1720.51, balance on hand, principal and interest, as a gift from the New York Section of the Woman's Auxiliary for pressing emergency dispensary work in France.

The American Fund for French Wounded was authorized to cable this sum at once, in consideration of the fact that their existing dispensaries, including the one established by the New York Section at Briey, were in excellent condition, while their mobile dispensary fund was confronted by the most urgent need for work among the refugees now returning in pitiable condition and in great numbers to certain distressing centers.

The committee sewing at Fund headquarters every week has had seven working days, with an enrollment of twenty. The average attendance was ten; largest attendance for any one day, thirteen; smallest attendance, eight. Interest in this activity is growing steadily and it is the intention of the committee to push the work vigorously for the next few weeks.

IN MEMORIAM

CORPORAL SHEPPARD B. GORDY

Sheppard B. Gordy, a brief biography of whom was printed in the January *Bulletin*, entered the employ of the Braden Copper Co. immediately on his graduation from the Sheffield Scientific School in 1912. He remained with this company four years, working up through the various grades to assistant foreman and foreman to one of the individual mines. The last year he was in its employ, he acted as general mine foreman. He was for a short time with the Chile Exploration Co. and then went with the Andes Exploration Co. (Anaconda) and remained with

CORPORAL SHEPPARD B. GORDY.

the latter, doing mine exploration and development work, until he sailed for home in June, 1918, to give a more personal and active service to his country in her need.

He declined a tender of induction into an officers' training camp, at the urgent request of Professor McClelland supplemented by Mr. Potter, because they demonstrated to his satisfaction that he could give more valuable service to his country in helping out with the aircraft production. Being within the draft age, in order to carry out this plan, it was necessary for him to be called by his Local Board and sent to camp. This call came Aug. 26. Two weeks before that time he had gone to Dayton, Ohio, to begin the study of aircraft production, and was sent by the Dayton Board to Camp Sherman, Chillicothe, Ohio, where he died of pneumonia on Oct. 9.

LIEUTENANT S. A. LANG, C. E. B. A. SC.

From "Knots and Lashings," of Oct. 10, 1918, the military publication of Canadian Engineers' Training Depot, St. Johns, Que.

During the early hours of Sunday morning last (the 6th inst.) there passed from our midst one of the most affable and estimable officers who, during our brief connection with the Depot, it has been our fortune to meet.

Sidney A. Lang was born in Ontario in the year 1884 and lived in Toronto for a number of years. He attended Toronto University, where he displayed remarkable ability, and after graduating followed the profession of mining engineer. Being young and endowed with the spirit of adventure, he followed his profession in the mines of Chile and Peru; he could speak Spanish fluently. Always a reserved man, of refined tastes, it was difficult to induce him to relate some of his adventures in those countries so shrouded in mystery and romance. He joined the Canadian Engineers in Toronto as a sapper and shortly after came to this Depot.

We remember him as a messmate, as a roommate, and when we rubbed shoulders with him on the square, for his kindly thought and unassuming manners.

The Spanish grippe has claimed many from our depot. As we read down the names we pause here and there to recall some incident to establish permanently in our memory as a link to bind us, the living, with the dead.

> "And there's one name we cannot pass
> So we pause, and ponder awhile.
> And recall all his cheery words,
> And his smile—his perpetual smile."

Men detained in the Quarantine Camp will have cause to remember him too, for he displayed his gentlemanly bearing and courtesy to all he came in contact with.

DIED IN SERVICE

Bailey, Lewis Newton, Master Engineer, Senior Grade, 4th Regiment, U. S. Engineers, Headquarters Company, died of pneumonia at Camp Merritt, N. J., on Apr. 30, 1918.

Baird, Louis, Lieut., Royal Field Artillery, British Army, died on the battlefield in 1915.

Ballamy, John H., Capt., 103d Engineers, killed in action near Fismes, Aug. 9, 1918.

Bowles, Martin F., 2d Lieut., Co. B, 355th Infantry, killed in action, Sept. 3, 1918.

Burt, Andrew, died in active service, 1916.

Cobeldick, William Morley, Royal Engineers, died from gas poisoning on Oct. 7, 1915.

Dougall, Ralph, 4th University Co., Princess Patricia Regiment, killed in action early in the war.

Evans, Alfred Winter, Lieut.-Col., New Zealand Rifle Brigade, D. S. O., D. C. M., killed in action on Oct. 12, 1917.

Gordy, Sheppard B., died in Service, Oct. 9, 1918.

Gorman, Thomas C., Lieut., Canadian Engineers, killed in France, Mar. 18, 1918.

Hague, William, 1st Lieut., Engineer Officers' Reserve Corps, died in active service, Jan. 1, 1918.

Hall, William T., Capt., Royal Flying Corps, killed in action, May 19, 1917.

Harbach, Herbert Moore, died of pneumonia, 1918, at Camp Meade, Md.

Heine, Bernhardt E., Lieut., Aviation Service, died from accident at Fort Sill, Okla., Aug. 10, 1918.

Irving, John Duer, Capt., 11th Engineers, A. E. F., died July 26, 1918, while on active service in France.

Lang, Sidney A., Lieut., Canadian Engineers, died Oct. 6, 1918, of influenza, at the Engineers' Training Depot, St. Johns, Quebec.

Ohnsorg, Norman Lloyd, died of pneumonia, Oct. 11, 1918.

Perry, Edward H., 1st Lieut., Co. D, 6th Regiment Engineers, U. S. Expeditionary Forces, France, killed in action on March 30, 1918.

Pretyman, Frank Remington, 2d Lieut., Royal Engineers, killed in action on June 17, 1916.

Reece, Fred. B., Capt., Royal Engineers, B. E. F., 232d Army Troops Co., killed in action.

Ringlund, Soren, Medical Department, Fort Logan, Colo., died suddenly in camp on July 24, 1918.

Roper, George, Jr., Lieut., Royal Flying Corps, killed in aeroplane accident in England on May 25, 1918.

Smyth, Raymond Weir, died of influenza at the Navy Yard Hospital, League Island, Philadelphia, Sept. 27, 1918.

NEWS FROM MEMBERS IN SERVICE

H. McD. Lorain says in regard to his son, Captain S. H. Lorain; "It might be of interest to you to know that, although but 23 years of age, my son is captain of Co. C 107th U. S. Engineers, Thirty-second Division. He landed in France about the middle of February, 1918, and was commissioned a captain on Sept. 5, 1918. He started for the front the latter part of June and was there continuously until the armistice was signed, on Nov. 11, being on the front lines in the Argonne at that time. He is, at present, in Coblenz, Germany, with the Army of Occupation. Although much of his work was done under artillery and machine-gun fire, as well as airplane bombs and fire, he escaped without a scratch. Once, he was the only one of a group who escaped without a scratch from an exploding shell."

Lieut. Bernard H. Lasky, on a post card received a short time ago, gave the following brief record of his military career. "I have been serving with the 316th Engineers in France and in Flanders and had the satisfaction of being in the last big drive in Belgium which sent the enemy beyond Avaenarde and did much to increase their gait on their way to Brussels. On Oct. 1, I received a commission as second lieutenant and was assigned to Co. C of the 316th Engineers."

Capt. Harry A. Ambler, of the 30th Infantry, writes saying he is now at Ft. Sheridan, Ohio, in General Hospital No. 28. Captain Ambler was wounded while fighting in France with the A. E. F.

Major L. W. Wickes has just returned from France and is stationed at Camp Devens, Mass., with the 212th Engineers.

RELATIONS OF NATIONAL RESEARCH COUNCIL TO ENGINEERING SOCIETIES

At the University Club, New York, Jan. 23, Chairman George E. Hale and other officers of the National Research Council, gave a dinner to officers of the national engineering and other societies. About thirty persons were present, including officers of the National Research Council, the four Founder Societies, American Society for Testing Materials, Society of Automotive Engineers, Inc., Illuminating Engineering Society, United Engineering Society, and Engineering Foundation. Letters were received from the Western Society of Engineers, which also had been invited. Gano Dunn, vice-chairman of National Research Council, was toastmaster.

The proposed permanent organization of the National Research Council and possible methods of connection with the national engineering societies, either directly or through Engineering Foundation, were outlined. It was suggested that not only the four Founder Societies be represented in the Engineering Division of National Research Council, but also that the other national engineering societies be admitted to membership. It was proposed that the Engineering Division should have a chairman who should be an engineer of wide reputation and of the highest professional attainments who should devote his whole time to the establishment and development of the Division. Methods of organizing industrial research were discussed. At a subsequent meeting of the National Research Council, an invitation was issued to each of the national societies to form a research committee encouraging that committee to become active in the promotion of research within its respective field. Due recognition is to be given each committee in the general organization of the National Research Council.

Dr. H. M. Howe, in a very interesting and comprehensive address, told of much important work that had been done by the various sections of the Research Council, as that of mechanical engineering in developing the often rather nebulous devices for helping win the war and putting them in such form that they could be of direct use to the military service. The section on metallurgy, till lately under Bradley Stoughton and now under G. H. Clevenger, did much valuable work in the improvement of helmets and body armor and made very extensive ballistic tests with refractory steels for this purpose. Important work was done in investigating the fatigue of metals and results of great moment were achieved. The committee on ferro-alloys, under J. E. Johnson, Jr., did important work in effecting economy of manganese in steel manufacture with a view to reducing the necessity for importation of manganese ore, thus releasing ships for other purposes. The section on electric welding has accomplished valuable results in the development of electric welding for ships, a new branch of industry of very great promise.

PERKIN MEDAL AWARDED TO DR. F. G. COTTRELL

On Friday, Jan. 17, the thirteenth impression of the Perkin Medal was presented to Dr. Frederick Gardner Cottrell, at a meeting of the New York Section of the Society of Chemical Industry, held at the Chemists' Club, in New York City. The presentation address was delivered by Dr. C. F. Chandler, Senior Past President of the Society. The medal was awarded for the recipient's work in the electrical precipitation of suspended particles in gases.

Dr. Cottrell's career, which is so familiar to members of the Institute, was sketched by Dr. Chandler. He told at some length of the experiments leading up to the final solution of electrostatic precipitation, which has done so much to solve the problem of smelter smoke.

The principal interest in Dr. Cottrell's speech of acceptance lay in his remarks about helium, the production of which has been so reduced in cost that it has practically supplanted the use of hydrogen for inflation purposes in war balloons. He said:

"Two or three weeks after war was declared in 1917, Dr. R. B. Moore attended a meeting of the American Chemical Society in Kansas City. At the general session, Mr: Seibel of the University of Kansas, gave a paper on krypton and xenon in some of the natural gases of Kansas. At the end of his paper, he expressed regret that at such a time, when everyone was thinking of war problems, his paper was of a purely scientific nature and had no practical bearing on the war. Dr. Moore immediately got up and said that he did not agree with Mr. Seibel. The presence of helium in those wells could, and should, have a very practical bearing on the war as this gas could be extracted in quantity from the natural gas and used for balloons and Zeppelins. He pointed out some of the natural advantages of helium over hydrogen, and quoted Sir William Ramsey's letter advocating the use of helium for airships. The general attitude of those present was one of scepticism, so he finally asked Dr. Cady for his opinion who stated that he believed the thing could be done, but was very doubtful whether it could ever be made practical on account of the cost."

Dr. Moore in a letter wrote: "That same day I talked to Dr. Parsons. who was present at the meeting and was returning to Washington almost immediately. I told him what had happened, and that I believed the matter should be taken up by the Bureau at once and presented to the War Department. He promised to do this as soon as he got to Washington; and I know that he did take the matter up with other Bureau officials."

Dr. Cottrell continued in part:

News of Ramsey's suggestions also reached this country through other channels and eventually came to our attention. Professors Satterly and Patterson of the University of Toronto commenced experimentation of the subject Jan. 1, 1916. Col. G. A. Burrell, who headed the research department of the Gas Warfare Service at the American University, tells me that Cady's experiments had also suggested similar possibilities to him.

U. S. BALLOON SERVICE INTERESTED

However, no definite step toward securing action seems to have been taken in the United States until June 1, 1917, on which date Messrs.

Moore and Burrell, at the time both of the Bureau of Mines, called on Colonel Chandler, in charge of the balloon service for the Army, and explained the whole subject to him. He was intensely interested, at once realizing its potentialities, and asked that a report be made to him, giving all available details. He also took the matter up with G. O. Carter, in charge of hydrogen plants for the Navy, who had had several years practical experience in the Linde Air Products Co. with the liquefaction and separation of gases by their process. Mr. Carter also immediately appreciated the importance of the subject and urged this upon the attention of his superiors in the Navy.

Up to this time in the whole world there had probably not been more than 100 cu. ft. of helium separated as a pure gas and its price in the small lots in which it was sold was at a rate of about $1700 per cu. ft.

About this time, I was called into the conference and was much impressed by the weight which the British Admiralty apparently laid upon the cost of separation of the gas as a determining factor in its practical availability. I was given to understand that they had figures on the basis of the well-known commercial process of gas by liquefaction and separation and were unable to see how production could be hoped for at less than $60 to $80 per thousand cubic feet, which they felt to be practically prohibitive for the program they then had in mind. It was at this stage that I suggested turning to Mr. Norton at least for a plan and estimate of what he thought might be accomplished along the new lines he had been following and we accordingly wired for him. On Monday, June 4, we spent practically the whole day in thrashing out the subject with the result that Mr. Norton was asked to act as a consulting engineer of the Bureau of Mines and prepare plans and estimates for an experimental plant.

Appropriation Made for Work

In due course, a formal report made by the Bureau of Mines was transmitted through Secretary Lane to the War Department, and although this report was as yet fragmentary and based on very inadequate data concerning the practical conditions to be met in the field, the Aircraft Board, on July 31, 1917, recommended an allotment of $100,000, half each for the Army and Navy, which became available for use of the Bureau of Mines on Aug. 4.

A detailed survey of coal conditions to determine the best available supply of natural gas for the purpose was at once begun, as also the preparation of working drawings for the experimental separation plant.

Helium versus Argon

The general supervision of this was, for a short period, at this time placed in the hands of Prof. W. H. Walker, of the Massachusetts Institute of Technology, who had come to Washington to assist in the chemical warfare work. I believe it was his suggestion, for purposes of military secrecy, to use the word "argon" as a code term for helium in all correspondence on the subject, it being thought that as real argon is also an inert gas, but too heavy to be of any value in balloons, and is already used to a large extent in the incandescent-lamp industry, this would serve as particularly effective camouflage. This has, in fact, so effectively confused the two words in the public's mind that it will take some little

effort to clear up the situation, and I would therefore bespeak your help in holding strictly to the true name helium whenever referring to the subject, now that all secrecy in the matter has been abandoned.

Even though we had been drawn into this work primarily through the desire of the British authorities to find a more economic process than those already known to them, it was now felt that the project had taken on such magnitude that the whole field should be carefully canvassed *de novo*. Mr. Burrell therefore communicated with the two well-established operating companies controlling, respectively, the Linde and Claude systems of gas liquefaction and distillation, to determine whether it would be possible to work out a plan of general coöperation and pooling of information and facilities for this specific war purpose. Due to questions of trade secrets and other business relations, this did not, however, prove practicable, though both companies expressed themselves as anxious to coöperate individually with the Government and entirely willing to undertake independently the erection of plants of their own respective designs at cost, or even less, and have ever since most cordially furnished every aid in their power to make the work as a whole a success.

BRITISH SEND COMMISSION

At this juncture a special commission from the British Admiralty, headed by Commander Cyprian D. C. Bridge, arrived in this country to collect data and exchange ideas on what was being done, and from the resulting conferences, the possible importance of the work in hand became so evident that the Aircraft Board, on Oct. 17, 1917, recommended that a further allotment of $500,000 be made jointly by the Army and Navy to permit of immediately starting construction of complete plants under all three processes.

In accordance therewith Mr. Norton was directed to prepare plans for a somewhat more complete plant embodying his process than had originally been contemplated. This brought the total estimated cost of the plant to about $150,000.

NORTON PROJECT SIDETRACKED

In making the actual allotment however, the Navy placed a restriction upon its half of the $500,000 that none of it should be used on the Norton project. When this was called to the attention of the Army, the latter decided to follow the Navy's lead, as they were very largely relying upon it for guidance and had designated Mr. Carter to represent them jointly in the matter.

While thoroughly realizing the expediency of the Navy's policy in making sure that the plants under established processes should be adequately financed and pushed with all possible rapidity to completion, the curtailment of support for the newer and more experimental portion of the program was a disappointment to those of us in the Bureau of Mines who had made a careful study of the Norton project and felt strongly as to the importance of giving it a thorough trial. The representatives of the British Admiralty also stated frankly that their main interest lay in the experiments on this process, as there was no particular doubt in their minds that either of the other processes could produce the gas, the only question being one of cost, and on this no one responsibly

connected with either of the two old processes had been willing to hold out any definite hopes of producing helium below the cost of $80 per 1000 cu. ft., which the Admiralty at that time considered prohibitive for its chief purposes. The matter was consequently taken up afresh with the Aircraft Board, and after considerable discussion, that body, on Dec. 11, recommended to the Army and Navy a further joint appropriation of $100,000 specifically for the Norton project. The Army immediately acquiesced with regard to its half but the Secretary of the Navy, feeling the need of further outside advice in the matter, requested the National Research Council to investigate the project with special regard to its theoretical soundness and its apparent chances for practical success.

COMMITTEE APPOINTED

The Council appointed for this purpose a Committee of five consisting of Prof. Harvey N. Davis, of Harvard University; Dr. Edgar Buckingham and Dr. Charles W. Waidner, of the Bureau of Standards; Dr. W. S. Landis, of the Air Nitrates Corporation; and S. L. G. Knox, consulting mechanical engineer and later scientific attaché of the American Embassy at Rome. This Committee, after very careful comparative study of the three processes, concurred in the Aircraft Board's recommendation of the additional $100,000, which was then immediately made available by the Army and Navy. This was early in February, 1918, the controversy over the support of the project having delayed the actual starting of construction on the Norton plant by something over two months.

In the meantime contracts had been closed with the Linde Air Products Co. and with the Air Reduction Co. for the construction and experimental operation of a Linde and a Claude plant respectively, each for an estimated daily production of about 7000 cu. ft. of helium, and construction was well along on each. These plants were to be located at North Fort Worth, Texas, and operate on a natural gas containing about 0.9 per cent. by volume of helium and of which the Lone Star Gas Co. was bringing some 20,000,000 cu. ft. daily through its pipe line from the wells at Petrolia, more than 100 mi. northeast of Fort Worth, to that city for domestic and industrial consumption.

QUANTITY AND PURITY INCREASE

The Linde Plant, costing in round figures $300,000, was the first to be contracted for and have its construction started. It commenced operation Mar. 6 and on Mar. 22 produced gas containing 28 per cent. helium. On Apr. 21, this purity had reached 50 per cent., the yield being at first small, but both quantity and purity steadily increased up to a maximum daily production, on Sept. 6, of 7755 cu. ft. of 67 per cent. purity, with average production of say 5000 cu. ft. at over 70 per cent. purity, which was then further purified in a second step to about 92 to 93 per cent. purity.

The Claude plant, costing about half as much as the Linde, commenced production some weeks later than the latter, and has also gradually increased its production and purity of product. Although up to date these are still considerably behind the performance of the Linde plant, a new still is just being installed at the Claude plant which it is hoped will materially improve both yield and purity of the product.

Due to present pipe-line limitations coupled with heavy consumption of fuel gas at this time of year, it has been necessary for some months past for the Lone Star Gas Co. to substitute for part of the Petrolia gas some from other fields carrying less helium, so that the helium content of the gas at present being treated at Fort Worth has fallen to between 0.4 and 0.5 per cent. by volume, which proportionately cuts down the production at both plants.

At the time of signing the armistice, the first shipment of 147,000 cu. ft. of 93 per cent. helium was on the dock about to be loaded aboard ship for Europe. This at the above cited pre-war prices would represent about $250,000,000 worth of gas.

A large part of the credit for the promptness with which this actual production was effected is due to Mr. Carter who was tireless in his efforts in pushing matters of priority, transportation, construction and production.

The Army and Navy have now jointly entered upon a larger production program under the immediate direction of the Navy, and have allotted some $5,000,000 for the purpose, including the construction of a new pipe line and additional units of the Linde plant at Fort Worth. General Squier, in an address before the American Institute of Electrical Engineers, recently stated that "Plants are under construction to give at least 50,000 cu. ft. a day at an estimated cost of not more than 10 c. per cu. ft." If present expectations of the Norton process are fulfilled, this cost may be still further greatly reduced.

GOLD MEDAL OF MINING AND METALLURGICAL SOCIETY AWARDED TO CHARLES EUGENE SCHNEIDER

The committee appointed by W. R. Ingalls, president of the Mining and Metallurgical Society of America, to nominate candidates for the annual gold medal of the Society consisted of E. G. Spilsbury, J. E. Johnson, Jr., and Bradley Stoughton. This committee recommended Mr. Schneider of the Creuzot Works in France for achievements in ferrous metallurgy, which recommendation was approved by the Society. From the report of the committee, the following facts relative to Mr. Schneider's career are taken:

Born in 1868, Charles Eugene Schneider undertook the management of the Schneider establishment in 1898, after the death of his father, Henri Schneider. Under his enlightened management, the Schneider establishments have been considerably extended, their activity being not only directed to increasing production, but also to spreading more and more their scope for action in all branches of industry—in metallurgy, mechanical and electrical construction, shipbuilding, artillery and ammunition, and in public works. During the 10 years preceding the war, the number of employees in these establishments, and without counting those of the more numerous subsidiaries, increased approximately 50 per cent.

While giving to peace industries all the attention necessitated by the progress in science and the continual improvement in industrial methods and products, Eugene Schneider, with a perspicacity that recent events have justified in a striking manner, especially directed his

efforts toward the creation in France of a war industry able to counterbalance, when the time came, the enormous power which the German war industry had established. The task was all the more difficult in that the French Government, supplied by its own arsenals, placed few orders with private concerns, and because the Krupp Works had known how to establish a kind of monopoly throughout the world, helped to this end by the now familiar commercial methods and through the fact that a French law, only abrogated in 1882, prohibited the export to foreign countries of war materials.

Already in 1895, the Schneider establishments made special efforts to realize and improve heavy and light field ordnance, known as quick-firing, the appearance of which called forth a revolution in the armament and tactics of modern artillery. After comparative trials, made in numerous countries, between Krupp and Schneider materials, the latter were adopted (in spite of Krupp's influence and prestige), owing to their superiority, duly ascertained by military commissions. At the time of the breaking out of the European war, most nations which do not do their own manufacturing had replaced Krupp artillery materials by those of Schneider; successive failures in the materials of the German firm, reports of which had been spread broadcast, sanctioned the triumph of the French manufacturer, confirmed by the present war.

When the war began, the development reached by Mr. Schneider in the manufacture of war materials proved extremely helpful to the French Government. In the Schneider Works, not only units of various calibers were found to be completed, or in the course of manufacture, for foreign governments, but also shops ready to immediately undertake artillery and ammunition manufacture and a competent staff for these difficult tasks; a specially trained staff to assist in starting numerous other shops which were not familiar with this kind of work.

The Schneider Works and their many subsidiaries which, since mobilization, have been exclusively devoted to war work, in spite of labor difficulties, employ at the present time about 150,000 workmen. The Creuzot Plants, which are the oldest and most important of the Schneider Works, employ in addition to local labor, reduced through mobilization, Arabian, Moroccan, Anamite, Chinese, Spanish workmen, etc. Women constitute now about one-third of the labor.

The war materials, delivered in very large quantities during the war to the French and Allied governments, are of the most varied types: Field guns and howitzers (heavy and light types), siege guns, large caliber guns on railway mounts, tanks, shells, cases, fuses, explosives, torpedoes, sights, submarine and aeroplane engines, armorplate, etc. Not only in France, but in Russia, Italy and England, Schneider et Cie.'s engineers have initiated numerous works for war manufacturers, especially in the preparation of special gun and shell steels. Also the American Government adopted for its ordnance the 155 and 240 mm. howitzers and railway mounts for large caliber guns, the Schneider model. This ordnance brilliantly proved its superiority on European battle fields and is at the present time being manufactured in U. S. arsenals, with the technical help of specially trained agents from the Schneider Works.

Besides the technical and industrial development of the Works, Eugene Schneider has given his attention to social economics as begun by his ancestors for the welfare of their employees. All questions pertaining to the interest of workmen have been the object of his constant

attention and, very often, received solutions which were very much in anticipation of recent laws. These institutions of social economics can be summed up as follows: Schools, technical instruction, evolution of salaries, inducements to saving, old-age pensions, allowances for the sick and the wounded, medical attention, hospitals, hygiene and safety conditions, mutual societies, etc.

Mr. Schneider was elected to the presidency of the British Iron and Steel Institute for the year 1918.

DISMISSAL OF PUBLIC SERVICE COMMISSION ENGINEERS

On Jan. 6, 1919, an urgent meeting of the Executive Committee of the Engineering Council was called to determine what action the Engineering Council could take concerning the sudden dismissal, by the Public Service Commission for the First District of New York, of approximately 350 engineers and assistants engaged on subway construction. This dismissal was forced by action of the Board of Estimate and Apportionment of the City in the adoption of a segregated line budget. It was decided that a hearing should be held, if suitable requests therefore were made. Communications having been received from the Acting Chairman of the Public Service Commission, American Society of Civil Engineers, Brooklyn Engineers' Club, the Municipal Engineers of the City of New York, also a petition signed by more than 50 engineers, a special committee was appointed and a hearing held in Engineering Societies Building Jan. 14. The members of this committee were Harold W. Buck, Chairman, C. A. Adams, C. W. Baker, N. A. Carle, George J. Foran, Allen Hazen, Clemens Herschel, Alex. C. Humphreys, D. S. Jacobus, J. F. Sanborn, J. Waldo Smith, and Herman Aaron, Counsel. To this hearing were invited the City authorities, engineers, and civic associations interested. There was an attendance of about 50 persons, and the facts of the case were well presented. A printed statement of the findings was sent to the Board of Estimate, the Public Service Commission and its engineers, the Governor, more than 100 civic and trade associations in New York, many engineering societies throughout the country, daily newspapers, and the technical journals, as well as the representatives on Engineering Council. At the end of January, the City authorities made provision for restoring most of the engineers to their positions and continuing the subway construction. Some of the dismissed engineers, it is reported, will receive pay also for January. Letters recently received from the Acting Chairman, the Chief Engineer and the Engineer of Subway Construction of the Public Service Commission expressed appreciation of Council's efforts, and stated that they had been effective.

ALFRED D. FLINN, *Secretary.*

ANNUAL MEETING OF AUTOMOTIVE ENGINEERS

Efficiency was the keynote of the annual meeting of the Society of Automotive Engineers that was held in New York on Feb. 4–6. The influence of the war was also very evident at each meeting, in both the papers and the discussions. The Thursday morning session was devoted

to the discussion of fuels, the subjects ranging from More Efficient Utilization of Fuel, by Chas. F. Kettering, to Consideration of Mexico as a Source of Petroleum and Its Products, by E. De Golyer. While the opening session, Wednesday morning, was of a general nature; the first afternoon session was devoted to the automobile and the second to aircraft.

The officers for the coming year are: President, Charles M. Manly; first vice-president B. B. Bachman; second vice-president, representing motor car engineering, E. H. Belden; second vice-president, representing aviation engineering, Elmer A. Sperry; second vice-president, representing tractor engineering, T. B. Funk; second vice-president, representing marine engineering, John J. Amory; second vice-president, representing stationary internal combustion engineering, L. S. Keilholtz; members of the Council to serve for two years, E. A. DeWaters, David Fergusson, Edward A. Johnston; (to serve for one year), Charles S. Crawford, J. V. Whitbeck, Treasurer, Charles B. Whittelsey.

PRIZE ESSAY CONTEST IN INDUSTRIAL ECONOMICS

The National Industry Conference Board offers a prize of $1000 for the best monograph on any one of the following subjects:

1. A practicable plan for representation of workers in determining conditions of work and for prevention of industrial disputes.
2. The major causes of unemployment and how to minimize them.
3. How can efficiency of workers be so increased as to make high wage rates economically practicable?
4. Should the State interfere in the determination of wage rates?
5. Should rates of wages be definitely based on the cost of living?
6. How can present systems of wage payments be so perfected and supplemented as to be most conducive to individual efficiency and to the contentment of workers?
7. The closed union shop *versus* the open shop: their social and economic value compared.
8. Should trade unions and employers' associations be made legally responsible?

NEW MILITARY ENGINEERING SCHOOL

A new Military Engineering School has been established at Camp A. A. Humphreys, Virginia. This camp was used throughout the summer and fall of 1918 for the Engineering Officers Training School in preparing engineer officers for the United States Army. The camp and the courses prescribed were laid out on an ambitious scheme, which since the armistice has been signed, have been directed wholly toward the permanent establishment of an Engineering Training School for Officers of the regular Army.

Those young officers who were graduated from West Point at the end of a two-year course, necessitated by the emergency, have been ordered to Camp Humphreys to complete their engineering education.

Major-General William M. Black, Chief of Engineers, conceived this idea of a school which has a unique curriculum. The student will not first be taught the theory from books and later taught how to apply his learning practically. He will first be given practical object lessons and see his problems worked out by the building of bridges and the construction of different engineering problems, etc. He then will go to his books and study the theory with his mind full of pictures obtained from his field work.

The army officers who have acquainted themselves with this preliminary experiment at Camp Humphreys are enthusiastic over it, and the Military Affairs Committees in Congress are very well-disposed toward the ideas of the school. No one who knows General Black can doubt its ideals, and no one who knows what the E. O. T. S. did toward making engineer officers out of civilian engineers can doubt the ultimate results of the work proposed.

RESEARCH GRADUATE ASSISTANTSHIPS AT THE UNIVERSITY OF ILLINOIS

At the close of the current academic year, there will be eight vacancies to be filled in research graduate assistantships which are maintained by the Engineering Experiment Station of the University of Illinois. In addition to these assistantships, there are available two research graduate assistantships in gas engineering, which are supported by the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $500 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry.

An appointment to the position of Research Graduate Assistant is made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Not more than half of the time of a Research Graduate Assistant is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study.

Nominations to these positions, accompanied by assignments to special departments of the Engineering Experiment Station, are made from applications received by the Director of the Station. The nominations are made by the Executive Staff of the Station, subject to the approval of the President of the University. Nominations are based upon the character, scholastic attainments, and promise of success in the principle line of study or research to which the candidate proposes to devote himself. Preference is given those applicants who have had some practical engineering experience following the completion of their undergraduate work. Appointments are made in the spring, and they become effective the first day of the following September. Vacancies may be filled by similar nominations and appointments at other times.

INTERNATIONAL CONTROL OF MINERALS*

The annual world production of minerals approximates 1,700,000,000 tons, over 90 per cent. of which consists of coal and iron. Of this amount about two-thirds is used within the countries where the minerals are produced and one-third is shipped to other countries. The movement of most of these minerals, though, shows a rather remarkable concentration. For instance, manganese moves from three principal sources and converges at four or five consuming centers; chromite and tungsten move from two principal sources.

The United States is more nearly self-sustaining in regard to mineral commodities as a whole than any other country on the globe; but the interests of conservation call for an international viewpoint in the handling of our mineral resources. There is perhaps as much need of specializing in mineral output as there is of specializing in manufacturing. The thought that every country on the globe should be self-sustaining in regard to mineral supplies is of somewhat the same order as the thought that every family should produce all its own raw materials rather than take advantage of the more favorable conditions existing elsewhere and so specialize in human effort.

Extension of international control of minerals seems to offer possibilities of loss and gain—loss through a considerable sacrifice of national trade and a narrowing of the field for private initiative in trade; gain through the possibility of attaining certain ends which are attainable only by international agreement, such as an allocation of supplies which will be to the advantage of the greater number of nations rather than to the advantage of the few that are strong enough to dominate the situation. The interests of conservation clearly require international control. Moreover, the lesson of the war points to the necessity of overhauling old international understandings and machinery, even though such a task would encounter great difficulties, not the least of which lie in the persistence of human habits and inertia. Whether the time has come to establish a league of nations with economic control can be determined only by our individual and collective answers to the question whether we are willing to make the necessary economic sacrifices, individually and nationally, in the interest of world harmony. The mineral industry should fully understand that, with international control, efforts to promote export will need to be modified and curtailed; that expansion of our trade in many lines will mean equivalent loss of trade to other nations; that the almost universal conception that expansion of foreign trade is a meritorious aim and end in itself, without regard to its effect on other countries, will need revision.

MEMORANDUM FOR THE BULLETIN

Volume LIX has now been shipped to all members of the Institute and should be received in advance of this Bulletin.

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* Abstract from a Bulletin published by the U. S. Geological Survey.

COLLECTION OF WAR ENGINEERING MATERIAL

At the office of the Chief of Engineers, Washington, there is a unique collection of engineering material used and developed in the present war. It is a most interesting group of war devices, from the special trench shovel that excavates both gas and water, to the standard gage locomotives that were sent to France so complete that they were lifted from the ships by cranes, placed on the rails on shore, filled with water, fired up, and moved out from underneath the cranes under their own steam. Everything is exhibited either by models, or by photograph where the original samples are too large to admit of demonstration in an ordinary office.

The forestry section has an interesting exhibit of the wonderful work done in France; where, owing to the shortage of coal and the necessity for burning wood, the Forestry Unit of the A. E. F. in one month stacked up 60 mi. of cord wood (80,000 cords); also cut 6.6 mi. of timber, stacked 12 ft. long, and 10 ft. high, containing 50,000,000 board feet of sawed timber.

The question of portable searchlights for battlefield illumination has been most successfully grappled with by the engineers, the latest development being a 60-in. open-tube searchlight weighing 900 lb., including the trail, with an efficiency far ahead of any searchlight known. The sound and flash ranging devices comprise aerial, surface, and subterranean. An aerial 9-ft. paraboloid, to locate aircraft, mounted on a trailer truck was produced at a cost of $900; its weight was 1300 lb. as against a similar French machine weighing 7000 lb. and costing $1500. There have also been devised surface ranging devices employed in locating enemy guns by recording the difference in time required for sound to move from its source to specially constructed electric receivers situated at predetermined points. In the flash ranging set, a specially constructed telescope, that is trained upon any visible target, electric signals from observers are carried to the operator, who sits before a map and by triangulation and the signals from the observers is able to find the exact location of the enemy batteries. The subterranean set is merely two geophones attached to a stethoscope, by which the operator locates mining, sapping or any ground noise.

The military mapping section shows contour maps which give a very accurate idea of the earth surface by a simple use of the air brush which indicates all depressions and rises. In the accessories section there is a wealth of small material, including engineers' acetylene tent outfits, flare lamps, trench shovels; and the like.

HOOVER CALLS FOR CLOTHING

Herbert Hoover, head of the European Relief Administration, has cabled the American Red Cross that an immediate supply of clothing of every kind is absolutely vital to the health and life of "millions of men, women, and children freed from the German yoke."

In view of this situation the Red Cross announced tonight that it would conduct a countrywide campaign in March and hoped to obtain 10,000 tons of clothing, shoes, and blankets.

PERSONAL

The following is an incomplete list of members and guests who called at Institute headquarters during the period Jan. 10, 1918 to Feb. 10, 1919.

Walter F. E. Barcus.
Capt. D. H. Bradley, Jr.
Melvis Buigger.
Eugène Coste, Calgary, Can.
C. W. Cromwell, Warren, Ariz.
E. O. Daue.
Capt. H. W. Edmondson.
E. W. Engelmann, Hayden, Ariz.
C. Mason Farnham.
Lt. C. W. Frith, Salt Lake City, Utah.
John T. Fuller, Honesdale, Pa.
Walter A. Funk, Idaho Sp., Colo.
Major W. R. Grunow, New York, N. Y.
A. W. Hackwood, Butte, Mont.
Lt. Nathaniel Herz, New Haven, Conn.
Ralph T. Hirsh, New York City.
O. P. Hood, Washington, D. C.
E. B. Hopkins, Houston, Tex.
Hugh C. Ingle, Pensacola, Fla.
Capt. Wm. F. Jahn.
Roswell H. Johnson, Pittsburgh, Pa.
Jesse L. Jones, Pittsburgh, Pa.
Edgar Kidwell, Berkeley, Cal.
D. H. Ladd, Detroit, Mich.
Raymond B. Ladoo, Cambridge, Mass.
W. H. Landers.
David Lasner, Elizabeth, N. J.
J. M. Lilligren.
Lt. Wm. J. Linn, Chicago, Ill.
Lt. C. K. McDonald, U. S. N. R. F.
Major John DeN. Macomb, Bayhead, N. J.
Samuel Melitzer, New York City.
T. C. Merriman, New Haven, Conn.
Wm. J. Millard, Tulsa, Okla.
Benj. L. Miller, Bethlehem, Pa.
S. B. Patterson, Jr., Allentown, Pa.
Lynn L. Pomeroy, New York City.
W. E. Pomeroy, New York City.
G. M. Ponton, Ottawa. Ont.
Wallace E. Pratt, Ft. Worth, Tex.
Harold L. Rau, Milwaukee, Wis.
Lt. E. J. Ristedt, Camp Merritt.
George M. Ryall, Los Angeles, Cal.
D. B. Scott, Mogollon, N. M.
W. H. Staver.
Douglas B. Sterrett, Washington, D. C.
J. A. Stewart, Minneapolis, Minn.
R. H. Summer, Wilmington, Del.
W. G. Swart, Duluth, Minn.
Kirby Thomas, New York City.
Capt. H. D. Trounce, San Diego, Cal.
L. Unger, New York City.
George F. Vivian, Butte, Mont.
R. A. Walter, Reading, Pa.
Lt. R. G. Wayland, Chehalis, Wash.
R. J. White, Wallace, Idaho.
J. S. Wroth, Albuquerque, N. M.

Herbert Hoover, General Pershing, Ambassador William G. Sharp and **Admiral William S. Benson** were speakers to-day at the annual luncheon in honor of Washington's Birthday, given by the American Club of Paris at the Palais D'Orsay.

H. S. Adkins announces his connection with the First Creek Coal Co. at Blue Diamond, Ky.

Herbert W. Alden is vice-president of the Timken-Detroit Axel Co. at Detroit, Mich.

Carl A. Allen has accepted a position with the U. S. Bureau of Mines, Salt Lake City, Utah.

Clarence W. Andrews is now employed with the American Steel Foundries, Alliance, Ohio, in the open-hearth department.

W. S. Ayres, of Hazleton, Pa., has been given the degree of Doctor of Science by Lafayette College. At the same time the degree Doctor of Laws was conferred upon General Peyton C. March, Chief of Staff, Hon. James M. Beck, of New York, and Hon. Frank H. Sommer, Dean of the School of Law of New York University.

E. E. Barker has been transferred to Morococha as superintendent of the mines of the Cerro de Pasco Copper Corp.

Albert E. Blair, who during the war represented the Procurement Division of the Bureau of Aircraft Production of the United States War Department, is now located at 3a de los Heroes 45, Mexico, D. F.

Frank A. Blakeslee, has removed from Oakland, Cal., to Milwaukee, Wisconsin.

Frederick K. Brunton has been transferred from the Morenci Branch to the Copper Queen Branch of the Phelps-Dodge Corp.

Arthur W. Burgren is with the American Smelting and Refining Co. at Matehuala, S. L. P., Mexico.

Walter Carroll, lately discharged from the service, has accepted a position with the B. F. Goodrich Rubber Company at Akron, Ohio.

Raúl Chávez is at present geologist for the Twin State Oil Co. at Tulsa, Olka.

E. A. S. Clarke has resigned from the Lackawanna Steel Co. and has accepted a position with the Consolidated Steel Corp., 165 Broadway, New York City.

Roy L. Cornell, recently with the Emerald Isle Copper Co. is resident engineer with the Standard Minerals Co. at Kingman, Ariz.

Percy G. Cowin, 2d Lt. A. S. S. R. C., received his discharge from service recently and has resumed his duties with the E. J. Longyear Co., Minneapolis, Minn.

J. W. Crowdus, recently discharged from the service, has returned to his consulting practice, El Paso, Tex. As first lieutenant of Engineers he was attached to the General Staff Mechanical Section, Division of Purchase, Storage & Traffic, Washington, D. C.

W. M. Dake, Jr., formerly engineer for L. F. Rains, has been appointed general manager of the Blazon Coal Co., at Point of Rocks, Wyo.

Alfred J. Deischer, vice-president of the Empire Gas & Fuel Co. will, beginning Feb. 10, engage as a producer in the oil and gas business with offices at 100 W. 59th St., New York City.

Fred W. Denton is now vice-president of the Copper Range Co. with offices at 82 Devonshire St., Boston, Mass.

E. H. Dickenson, formerly assistant superintendent of mining and prospecting for the Tata Iron and Steel Co. has been appointed general manager of mines for that company, at Sakchi, India.

H. W. Doennecke has accepted the position of metallurgist with the Mineral Point Zinc Co. at De Pue, Ill.

D. A. Dutton, recently of Golden, Colo., is at present working for the Primos Exploration Co., at their mine, the Urad, at Empire, Colo.

Harold B. Fell received his discharge from the army a short time ago, having been a major in the 73d Field Artillery, and has accepted a position as general manager and treasurer with the Peerless Steel Co. at Ardmore, Okla.

Hallard W. Foester has moved from Nampa, Ida., to Esqueda, Son., Mex., care of Tigre Mining Co.

John M. Fox is superintendent at the Belmont Wagner Mining Co., with offices at Telluride, Colo.

E. D. Gardner was transferred to the Bureau of Mines on Nov. 1, having previously been with the Forest Service at Missoula, and has been assigned as engineer in charge of one of the Bureau's Mine Reserve corps in the West.

T. H. Garnett is with the Mineral Point Zinc Co. at Galena, Ill.

Author H. Gill has removed from Ridley Park, Pa., and is with the General Chemical Co. at Marcus Hook, Pa.

Harry D. Griffiths is consulting engineer with the Kanbauk (Burma) Wolpam Mines, Ltd., at 34 Great St. Helens, London, E. C., England.

Charles E. Griswold is with the International Smelting Co., at Miami, Ariz.

Henry Groos is now with the Kentucky Rock Asphalt Co., Sweden, Edmonson Co., Ky.

Lauriston B. Herr, Jr., is with the Scrub Oak Mining Co., at Wharton, N. J.

Major A. Hibbert of the 3d Tunnelling Co., Canadian Engineers, B. E. F., France, has been fortunate enough to again be "mentioned in Despatches" and has also been awarded the D.S.O.

Ross G. Hinman has been honorably discharged from the army and has accepted a position in the testing department of the New Jersey Zinc Co.

Joseph P. Hodgson has been made manager of the Morenci Branch of the Phelps-Dodge Corp. at Morenci, Ariz.

L. F. S. Holland is connected with the Arizona Mines & Reduction Co. at 627 Citizens National Bank Bldg., Los Angeles, Cal., in the capacity of consulting engineer.

Dallas E. Ingersoll has resigned as superintendent of operation with the Northern Central Coal Co. and is now president of the Powhattan Coal Co. at Huntsville, Mo.

Capt. William T. Jahn returned to the United States on the steamer "Lapland" in January, 1919 after twelve months active service in France. He has accepted a position with the Dorr Co. at 17 Battery Place, New York City.

George A. Kennedy is in Mexico with the W. C. Laughlin Co., Miguel Lopez, Agent, at La Colorada.

Rowland King, having been discharged from military duty, is with the C. M. Fassett Co. at 207 N. Wall St., Spokane, Wash.

Karl F. Klein has accepted a position with the Andes Copper Mining Co. with headquarters at Casilla 230, Antofagasta, Chile.

Hugo E. Koch is with the Atlas Portland Cement Co. at Hannibal, Mo. having recently been at the Watertown Arsenal in the Enlisted Ordnance Reserve Corps, U. S. A.

William J. Millard is with the Eastern Oil Co., 201 Texas Bldg., Tulsa, Okla.

Homer I. Merricks is now with the Edmund T. Perkins Engineering Co. as superintendent of construction; his address is Box 119, Pekin, Ill.

Stuart C. Lawson is instructor in mining engineering at the University of Wisconsin.

Capt. James J. Lillie, U. S. Infantry, is expecting to be discharged shortly; on his release he will return to his former position as engineer with the Horn Silver Mines Co., Frisco, Utah.

Paul T. Norton, Jr., was discharged from the army on Jan. 2, 1919, and has taken a position as sales engineer, Case Crane & Engineering Co., at Columbus, Ohio.

J. Edgar Pew is now vice-president of the Sun Co. with headquarters in the American Exchange National Bank Bldg. at Dallas, Tex., having recently resigned his position with the Carter Oil Co. at Tulsa, Okla.

Guy M. Powell, formerly with the Central Iron & Coal Co., is employed at the Corona Coal Co , Coal Valley, Ala.

Wallace E. Pratt is now chief geologist at the Humble Oil & Refining Co., Box 1352, Fort Worth, Tex.

Arthur E. Remington is engineer on the staff of the American Engineering & Operating Co., operating a number of mines and mills in Mexico.

P. A. Robbins is now located at San Francisco, California, having recently removed from Tummins Ont., where he was employed at the Hollinger Mine.

John C. Rogers has left the employ of the Canadian Copper Co. and is now with the International Nickel Co. of Canada, Ltd., Copper Cliff, Ont., Canada.

Alan B. Sanger has accepted the position as engineer with the Winona Copper Co. at Winona, Mich.

O. N. Scott, of Toronto, has been in Vancouver the last ten months as assistant to Major Austin C. Taylor, Director of the Department of Aeronautical Supplies, Imperial Munitions Board. Mr. Scott expects to return to Toronto in March.

Fred LeVerne Serviss is now situated at Golden, Colo. as manager of the Keystone Drafting Co.

Henry B. Smith is with the New Britain Machine Co.

James W. Smith has resigned as general superintendent of the Gray & Davis Co., Inc., of Cambridge, Mass.

M. G. Spencer, formerly connected with the Midvale Steel Co. and later with the Watertown Arsenal, in the capacity of chief chemist, has joined the staff of the Electrical Steel Co. of Indiana, Indianapolis, Ind., in charge of metallurgical operation.

C. O. Stee has been appointed superintendent of the Cerro de Pasco Mines of the Cerro de Pasco Copper Corp.

H. D. Sultzer has received his discharge from the service and has resumed the duties of his former position, assistant engineer with the Anaconda Copper Mining Co., at Butte, Mont.

E. R. Swanson, having been recently released from the service, has accepted a position with the Duquesne Steel Foundry Co., at Corapolis, Pa.

K. B. Thomas resigned his position as superintendent of the sulphuric acid department of the Calumet & Arizona Mining Co., to accept a position as general superintendent of the Standard Chemical & Oil Company of Troy, Ala.

A. T. Thomson is with the Phelps-Dodge Corp. in the capacity of assistant to the President.

Capt. H. D. Trounce, formerly a member of the Royal British Engineers, but since July, 1917 with the U. S. Engineers has written on one of the most important and dangerous activities of the whole war—that of mining and sapping. The book, "Fighting the Boche Underground," describes this strange form of warfare under the trenches and No Man's Land with a great clarity and vividness. Capt. Trounce deals with this most thrilling subject, hitherto untouched by war writers, in a way which is no less informative because untechnical.

F. W. Varney recently moved from Salt Lake City, Utah, to Gazelle, Cal., with the Chalco Copper Co.

Robert Y. Williams has accepted the position of general superintendent of the coal department of the Delaware & Hudson Co., at Scranton, Pa.

Y. C. Wong is chemist with the American Smelting & Refining Co. at their Omaha, Neb., plant.

ENGINEERS AVAILABLE

(Under this heading will be published notes sent to the Secretary of the Institute by members or other persons introduced by members.)

No. 544.—Mining engineer, 39 years of age, graduate E. M. with extensive experience in the United States, Canada and Spanish-speaking countries. Good organizer, energetic and resourceful. Experience covers mining and milling of gold, silver, lead, copper, zinc and tungsten. At present a Captain of Engineers, U. S. A., expecting to be released shortly. Open for engagement as manager, superintendent or examining engineer. Correspondence and personal interview solicited.

No. 545.—Engineer and geologist, member, age 29 years, technical graduate and married. Six years' practical experience as surveyor, chief engineer and in exploration work in West, Southwest and Mexico. Speaks French and Spanish. Desires position with exploration company or as engineer and superintendent of small mine. Will be released from commission in United States Navy about February 1.

No. 546.—For staff position or manager. Member, married, graduate mining and metallurgical engineer, 18 years' experience in underground and metallurgical work on gold, silver, copper, lead and zinc ores. Details, references, and qualifications will be sent if requested, or may be seen at Institute office. Available immediately in United States or Canada. Would go reasonable distance for an interview if desired.

No. 547.—Member, experienced in mine operating, engineering, general contracting and constructing. Technical graduate, mining engineer, married, age 38 years. Many years' practical experience while advancing through different positions to manager. Best of references and rating. Desires change. Position with future. Can obtain results. Salary commensurate with position. Available on short notice.

No. 548.—Mining engineer, member, technical graduate, age 31, on military service since August, 1914, available after January 31. Best of references.

No. 549.—Mining or mechanical engineer with an extensive technical education covering mining, mechanical and metallurgical engineering, with a supplementary legal education and about 10 years' varied practical experience, who is familiar with the design, construction, operation and maintenance of power, mining, chemical, metallurgical and cement plants, and who has handled men in large numbers and work of considerable magnitude, is open for engagement.

No. 550.—Member, metallurgical engineer and superintendent, desires position with steel manufacturer or responsible company dealing in steel or its products. Technical graduate, now Captain U. S. A. but will soon be released. Salary $4500.

No. 551.—Mine superintendent, native born, 36, single, recently discharged from the army; 14 years' experience as miner, mill shift boss, assayer, chemist, surveyor, plant and mill sampler, foreman and superintendent in metal work, open for immediate engagement.

No. 552.—Graduate electrical engineer, 30 years old, married, wide experience of over 10 years. Has made industrial layouts, installing and maintaining them. Experienced in handling men. Desires position

as electrical superintendent or engineering manager with opportunity for advancement along executive lines. Salary $3000.

No. 553.—Member, age 33, married. Technical training. Eight years' experience as mining and contracting engineer, reinforced concrete and timber construction. Served since 1915 as engineer officer with British and United States armies. Open for engagement at once. Qualifications and experience may be consulted at the office of the Institute.

No. 555.—Mining and metallurgical engineer, recently discharged as Captain of Artillery after 12 months' active service in France, is open for engagement as manager or assistant, efficiency engineer or superintendent of gold and silver milling and cyaniding plants. Age 30, married, no children. Graduate engineer with 8 years' experience in the United States, Canada and Central America; able to speak Spanish and German and has a working knowledge of French. Record is one of efficiency.

POSITIONS VACANT

No. 373. Wanted.—Two mill and cyanide shift bosses who must be technically trained, thoroughly experienced along chemical and mill-operating lines. Must be energetic and of a caliber to take entire charge of mill in case of emergency and able to handle any technical questions that may arise. Plant consists of 400-ton stamp mill and cyanide plant. Working knowledge of Spanish desirable but not absolutely required. Salary $150 per month together with all other usual terms of regular contract. Location, Central America.

No. 374. Wanted.—A University in the Middle West desires, for its mining department, a professor proficient in the preparation of coal and ores and mining design.

No. 375. Wanted.—A University in the Middle West desires in its mining department a professor for a research position which requires not only a library and laboratory research man, but one who can mingle with mine operators and technical men and labor men and represent the university technically in State work.

No. 376. Wanted.—A number of salesmen to handle alloy machinery and tool steels in New England and also in Middle West. Men for this work should have a thorough understanding of heat treatment so as to be in a position to go into a customer's plant and demonstrate how various parts should be treated. A knowledge of mill practice is also very desirable, although not absolutely necessary.

No. 377. Wanted.—Sales engineer possessing working knowledge of Spanish and having mechanical engineering experience, though not necessarily a technical graduate, to represent concern manufacturing oxy-acetylene apparatus for welding and cutting metals; knowledge of the process desirable. Location, Cuba, Mexico, and South America. Salary depends upon man.

No. 378. Wanted.—Mining engineer, age about 28 to 30, to take charge of engineering work at mine in Mexico and also to act as assistant to mine superintendent. Salary $150 U. S. currency.

FORTHCOMING MEETINGS OF SOCIETIES

Organization	Place	Date
		1919
American Railway Engineering Association	Chicago, Ill.	Mar. 18–20
Society of Industrial Engineers	New York, N. Y.	Mar. 18–21
American Electrochemical Society	New York, N. Y.	Apr. 3–5
National Foreign Trade Council	Chicago, Ill.	Apr. 24–26
American Iron and Steel Institute	New York, N. Y.	May
American Institute of Electrical Engineers	Lake Placid, N. Y.	June

BIOGRAPHICAL NOTICES

HARRY B. BARREN

Harry B. Barren, born in Cleveland, Ohio, May 31, 1888, died in Indiana Harbor, Ind., on Mar. 18, 1918. After graduating from the Case School of Applied Science of Cleveland, class of 1910, he spent a year at the Youngstown, Ohio, plant of the Carnegie Steel Co. and the following two years with the National Tube Co. in Lorraine, Ohio. In 1913, he went to Indiana Harbor as assistant superintendent of the blast furnaces of the Inland Steel Co. Four months later, he was made superintendent. On Feb. 11, 1914, he was married to Miss Anna E. Jones in Cleveland and is survived by his widow and two sons, and by his parents Mr. and Mrs. H. A. Barren, of Cleveland, and a brother Kenneth, a lieutenant in the 309th Engineers, stationed at Camp Taylor, Louisville, Ky.

CHAS. H. JOHNSON

Charles Harmany Johnson died Dec. 10, 1918, at his home in New Castle, Pa., after an illness of more than four weeks brought about by a complete nervous collapse. He was born near Clinton, Lawrence Co. Pa., July 9, 1870, a son of George W. and Elizabeth A. Johnson. His parents moved to New Castle when he was two years old, where he attended the public schools of New Castle. He then attended Allegheny College, and later Massachusetts Institute of Technology where he graduated as a mining engineer.

For a year and a half after completing his work at Boston he was connected with the Mesaba Ore Range in Minnesota, and then returned to New Castle and became associated with his father in the operation of the old sheet mill, which was converted into a tin mill and later sold to the American Sheet and Tin Plate Co. Since that time he has been actively engaged with his father in the limestone business and other industries.

At the time of his death Mr. Johnson was general manager of the Pittsburg Limestone Co., the G. W. Johnson Limestone Co., the Lawrence Limestone Co., the Keystone Limestone Co., and the Mahoning Limestone Co., all of which have quarries in Lawrence, Butler, Blair and Armstrong counties and also in Maryland and West Virginia. He was president of the Johnson Bronze Co., the National Stone Co., and the

Bessemer Loam-Sand Co., and was vice president and a director of the Lawrence Savings and Trust Co.

In 1903, Mr. Johnson was married to Miss Grace Phillips, daughter of the late Thomas W. Phillips. Besides his wife and his father G. W. Johnson, he leaves five children, Charles H. Johnson, Jr., Phillips, Winifred, George W., and Thomas Phillips Johnson.

PAUL JONES

Paul Jones was born in Wilmington, Del., on May 11, 1881, and was educated in the schools of that city. He studied as a special student in mechanical and mining engineering and, in 1902, became a draftsman for the Diamond Steel Co., of Wilmington. Later he became engineer of tests, and then assistant to the superintendent of shops and steel products. In 1906, he entered the employ of E. I. DuPont de Nermours Co., Wilmington, his duties being in connection with the construction, design, and maintenance of power plants and power transmission systems and costs. Two years later he was employed by the H. C. Frick Co., Pittsburgh, Pa., as assistant engineer for the design of coal and coke plants, railroad trackage, and structures, power plants, etc. For the years 1909 to 1912, his services were loaned to the G. S. Baton Co., as construction engineer, where his duties were along the same lines. When he returned to the Frick Co., he was made plant superintendent of the Filbert works, which he completed developing and maintaining all plant operations. In 1914, he became associated with the Bosch Magneto Co, Plainfield, N. J., as works engineer. In the spring of 1918, he was commissioned a first lieutenant in the aviation section, Signal Reserve Corps, and assigned for active duty in the finance department. At the time of his death, Dec. 17, 1918, he was connected with the Air Nitrates Corporation at the New York Offices, having received his honorable discharge from the service.

J. KING McLANAHAN

J. King McLanahan, died at his home in Hollidaysburg, Pa., on Dec. 13, 1918, of diseases resultant from old age. Mr. McLanahan had been in failing health for a year or more but had only been confined to his bed for the past month. J. King McLanahan was born in Bedford county on Mar. 25, 1828, and until 16 years of age, spent a large part of his time at school. He then became a clerk in the office of Dr. Schoenberger, owner of Sarah furnace. His father and grandfather were both iron men, so in order to thoroughly qualify himself for this business he entered the Baldwin Locomotive works at Philadelphia as an apprentice in 1845. In 1848, he superintended the construction of the engine used on the inclined plane of the Portage railroad section of the Pennsylvania canal.

In the same year, in partnership with Michael Kelly, he established a foundry at Hollidaysburg, in which he retained his interest when, in 1851, he went to Cincinnati to become superintendent of the celebrated Shock Steam Fire engine works, where the first steam fire engine in Ohio was built. In 1855 he returned to Hollidaysburg and became a member of the firm of Watson, White & Co., and made all the plans and estimates for and superintended the building of furnace No. 1. He remained with the firm until its absorption by the Cambria Iron Co.

In the spring of 1857, William Stone replaced Michael Kelly as his partner in the foundry business; this association has continued to the present being the present McLanahan-Stone Machine Co. In 1887 Mr. McLanahan became interested in the Rodman furnace and Bloomfield ore banks and for years was one of the largest employers of labor in that section. From 1879 until 1882, he was manager of the Blair Iron Co. rolling mill and for a protracted period was a member of the firm of McLanahan, Smith & Co., in a rolling-mill business. He was one of the founders and a director of the Juniata Iron Co. and promoted the interests of that concern in the building of mills and factories. He was especially interested in the mining of brown hematite and was the pioneer in designing machinery for the treatment of this ore. For a number of years past he had been identified with the American Lime and Stone Co. and was owner of Highland Hall, one of the most successful schools for young women in the country.

On Feb. 21, 1857, Mr. McLanahan was married to Miss Mary Martin, who died Mar. 9, 1903. He is survived by two sons, M. Hawley McLanahan, a member of the firm of Price & McLanahan, architects, of Philadelphia, and J. King McLanahan Jr.; also by one brother, J. C. McLanahan, of Hollidaysburg, and four grandchildren: Helen S. McLanahan, Margaret and Elizabeth, and Captain Alexander McLanahan, an aviator with the American army in France.

WINFIELD SCOTT POTTER

Winfield Scott Potter, of Pittsburgh, Pa., died suddenly at the West Penn hospital, on Jan. 3. He is survived by his wife, Mary Butler Potter and two children, Mary Douglass Potter and Winfield Scott Potter, Jr.

Mr. Potter was a graduate of the Brooklyn Polytechnic Institute, class of '87, with the degree of bachelor of science, and of the Rensselaer Polytechnic Institute, class of '90, with degree of civil engineer. He was vice-president and director of the Manganese Steel Rail Co. of New York and affiliated with its subsidiary, the American Brake Shoe & Foundry Co. of New York. He spent a great many years in research work and discovered the art of rolling high manganese steel, and later obtained patents for rolling high manganese steel products in the United States, Great Britain, Canada, Austria and other foreign countries. The principal products were manganese steel rails and the manganese steel helmets used exclusively by the United States during the world war.

Mr. Potter spent considerable time in the steel industry in the Pittsburgh district, and was the founder and president of the Alloy Steel Forging Co. with its extensive works at Carnegie. He was a member of the Railroad Club of New York, the American Iron and Steel Institute, and the American Institute of Mining Engineers of New York, and of the Duquesne Club and Pittsburgh Athletic Association and of the Shadyside Presbyterian Church, of Pittsburgh.

S. M. RODGERS

S. M. Rodgers, metallurgist for the American Steel & Wire Co., at Pittsburgh, died on Sept. 17, at his home in that city. He was born, in 1860, near Wellsburg, W. Va. After graduating at Bethany college, he took post-graduate work in science at the University of Michigan

and returned to Bethany as a member of the teaching staff. Later, he engaged in other work and, in 1892, entered the employ of the Hainsworth Steel Co., Pittsburgh, as chemist, remaining with that company until its consolidation with the American Steel & Wire Co. Shortly after, he was transferred, as chief chemist, to the Newburgh Steel Works, Cleveland, and then to Worcester, Mass., where he served successively as chief chemist, superintendent of the open-hearth department, and superintendent of the North Works. From the last position, he returned to Pittsburgh as metallurgist for the Company. He was a member of the American Iron and Steel Institute, the American Society for Testing Materials, the Society of Automotive Engineers, and the American Institute of Mining Engineers. He is survived by his widow, two sons, and one married daughter. One son, Glenn P. Rodgers, is first lieutenant in the aviation corps in active service in France.

ROBERT SCHUBERT

Robert Schubert, born in Philadelphia, of German parents, spent three years in metallographic work with the Midvale Steel, four years with the American Steel Wire Co. at Ensley, Ala., and was with the Illinois Steel Co., Bethlehem Steel Co., and Carnegie Steel Co. Early in 1917, he was placed in charge of the chemical and physical testing laboratories of the Stavanger Electric Steel Works at Stavenger, Norway, and installed for them much modern testing apparatus. While in their employ, on a visit to Christiana, he suffered an attack of influenza and died, from pneumonia, in a few days in the hospital in Christiana.

ERNEST H. SIMONDS

Until the time of his death, Ernest H. Simonds was active in metallurgical operation and progress. He was the senior member of the firm Simonds & Latham, who were operating successfully upon refractory tailings products of Calaveras County, Cal., and elsewhere. Throughout his life he was a leader in the application of the orderly principles of science to the most difficult of economic and metallurgical problems.

Mr. Simonds was born at Fitchburg, Mass., 49 years ago. His parents, who came to the Pacific Coast to make their home, were of the older American stock. From their unswerving example he appears to have derived the trustworthiness, the force of character, and the outspoken and generous nature that characterized him throughout the busy days of his entire life. He entered the University of California as a student in mining in 1889 and graduated with distinction. After a short experience in subordinate capacities at engineering work, he was appointed assistant in the College of Mining at the University of California, becoming later instructor in metallurgy; this position he held for four years.

In 1898, Mr. Simonds discontinued his academic work. For some years, he conducted an assay and experimental laboratory at Montgomery St., San Francisco, from which successful projects emanated that defined his subsequent career. The laboratory, for some years, was abandoned for the larger experimental and productive work that he assumed elsewhere. His headquarters, however, he maintained at San Francisco throughout his practice. Mr. Simonds never was of a

robust nature. His energetic life left him no time to think adequately of himself or of repose and he fell a victim to influenza. During his brief illness, he was cared for at the Fabiola Hospital in Oakland, Cal., where he died Friday, Dec. 20.

Mr. Simonds is survived by a wife and two daughters who deeply mourn his loss and who will receive the profound sympathy of his colleagues, associates, and former students.

ALLISTER K. STEWART

Allister K. Stewart died Nov. 22, 1918, at St. Louis, Mo., after a two months illness. Mr. Stewart was a mining engineer and promoter for the past 30 years and at the time of his death, was with the Missouri Metals Corpn. and the Neuburg Holding and Development Co. He spent 12 years in Mexico, in charge of the properties that were located in Oaxaca and Sonora. He resigned to take charge of the management of iron-ore deposits in Oaxaca that he had located and had prospected thoroughly for more than 30 mi. These form the largest known deposits of high-grade iron ore in the world.

Mr. Stewart reported on iron mines in Wisconsin, also mines in Tennessee, Arkansas, Northern Canada, Colorado, Missouri, and California. He had a comprehensive knowledge of structural and economic geology, the genesis of ores, and the locations and occurrences favorable for their disposition; of mining districts, mines, and mining methods; etc. He was a prolific writer, his articles being sought by the leading scientific and mining journals. He is survived by a widow and one son A. K. Stewart, Jr.

CHARLES RICHARD VAN HISE

The sudden and untimely death of Dr. Charles R. Van Hise, late president of the University of Wisconsin, was one of the greatest losses, not only to the educational world and science of geology, for which he was a great leader and pathfinder, but also to the world of mining and allied interests, for which he was an adviser and helper who blazed trails and pointed out paths of development, which the practical men of engineering and industry will follow long after his death.

To the general public, Dr. Van Hise stood as a great educator who conceived and wrought out a new idea in the people's university of a commonwealth and as a great active mind that could not be held within the bounds of education and science but, by its own bigness and broadness, was forced into the contemplation of the larger affairs of the nation. To the engineering profession, Dr. Van Hise will be remembered as a tireless worker who solved some of the most complex problems in geology and the development of mineral resources and recorded these findings in a form that is of lasting value to those who follow him in similar labor. In this combination of thinker and worker, educator and economic student, scientist and practical engineer, lies Dr. Van Hise's contribution to his generation.

As an educator, Dr. Van Hise attained perhaps his widest recognition, for in the University of which he was president he evolved and accomplished a new idea, which caused it to be called, in 1908, by President Eliot of Harvard, "the leading State University." At the time of his sudden death, Nov. 19, he was just completing fourteen years as president

and forty-three years as student and teacher in the University. His entire life of 61 years had been devoted to his State and its University. He was the first alumnus of the University and the first Wisconsin-born citizen to become its president—and he enjoyed the longest term as president of the institution. Since his graduation from its College of Engineering in 1879, he had been constantly a member of its faculty. As Chief Justice John B. Winslow, of the Wisconsin Supreme Court said at the time of President Van Hise's death, "Wisconsin has had many able sons, men who have served their Country and their State with distinguished honor in various fields of effort, but among them all none, I believe, has rendered greater service in his time than President Van Hise. The University will be his true monument, for to him, more than to any one person, we owe the present commanding position of that great institution."

What his "new ideal of a State University" was may be best expressed in the words which he used to outline it in his inaugural address in 1904. "I shall never be content until the beneficent influence of the University of Wisconsin reaches every family of the State. This is my ideal of a State University. When the University of Wisconsin attains this ideal, it will be the first perfect State University. . . . The University of Wisconsin desires to prevent that greatest of all economic losses to the State, the loss of talent. To prevent this loss of talent, the University must not only provide for those who come to Madison for instruction, but must go out to the people of the State with the knowledge which they desire and need." Hence it was said early in his administration that "the boundaries of the State are the campus fence."

To engineers and scientists among his colleagues and associates, it has always seemed that his achievements in all lines—education, geology, public thinking—have shown the influence of his engineering training and point of view. He was educated as an engineer, his first degree was in engineering, his first teaching work was in metallurgy, and it was not until later that he turned to mineralogy and geology. Throughout his life's work he kept the engineer's point of view, as could be readily seen in his conduct of the University, his geological researches, his writing on public questions, and his attack on concrete problems. His continued and constant interest in engineering matters was evidenced strikingly by his appointment, in 1915, as chairman of the committee of the National Academy of Science to investigate causes and suggest remedies for the great slides of the Panama Canal.

His first college teaching was as instructor in metallurgy, a work which he carried on from 1879 to 1883. About that time his interest grew over toward the field of geology and, in 1888, he was holding the chair of professor of mineralogy. Two years later, he was professor of archean and applied geology; and in 1892, he was also lecturing as non-resident professor of structural geology at the University of Chicago while continuing to occupy the chair of geology at Wisconsin. This change of interest from engineering to geological and mining problems grew out of his close association with Professor R. D. Irving, who was then chairman of the Department of Geology and was carrying on investigations for the United States Geological Survey in the Lake Superior region. His association with Dr. Irving led him into the investigation of this region, and, at Professor Irving's untimely death at the age of 39, Dr. Van Hise took up his work and carried it on toward completion.

In the solving of the problems of the Lake Superior region, Dr. Van Hise showed at its best his remarkable mental grasp and his tireless energy. The Lake Superior region is one of great complexity from the geological standpoint. Being a region of great economic importance, because of its ores of iron and copper, it was important that the geology be thoroughly mapped and studied. The problems and conditions met by Dr. Van Hise in this work were largely new ones and, with his tireless love of hard work, his boundless fund of physical energy, and his wonderful resourcefulness and vision, he met and solved these difficult problems to the great benefit of the mining industry, and with the spirit of the true student of science put together the results of his studies to the lasting benefit of the science of geology. The Lake Superior rocks as a whole are very ancient and have been contorted and deformed and altered to such an extent as to present many difficult problems. In working out the complicated structure of the region, Dr. Van Hise had to blaze new trails and develop new principles for the deciphering of complicated structures. This work has made him a leader in the field of structural and dynamic geology. Similarly, the great variety of the rock alteration that he found in this interesting region led to the development of fundamental principles, which he has summarized in one of his most important publications, "A Treatise on Metamorphism," which is recognized as the classical work on that subject. The interest in pre-Cambrian geology that grew out of his work in the Lake Superior region led to studies of other areas of pre-Cambrian geology and for many years Dr. Van Hise was in charge of the division of pre-Cambrian geology for the United States Geological Survey.

Dr. Van Hise was one of the small group instrumental in the creation of the Geological and Natural History Survey of Wisconsin and was closely identified with the Survey until his death. From 1903 until 1918, he was president of its board of commissioners and interested himself in all phases of geological work in the State; not only that leading to the development of mineral resources, but just as keenly in the study of the way in which the surface of the State has been carved out through the ages. It was on his suggestion that the State Geological Survey started the present state highway work and carried it on until the State Highway Commission was created.

In his later years, his interest in mineral resources became more broadly philosophical as his widening experience taught him the tremendous part played by these resources in the development of civilization. He saw keenly the limited nature of many of these resources and that the welfare of future generations was dependent on their possession. This led him to bend his full energies to the propaganda for wise use and curtailment of waste by the present generation—to the development of conservation in state and nation. Out of this interest grew many other public services relating to government problems, so that at his death the nation found him writing, not on scientific problems or upon conservation, but upon regulation, the trust problems, and other great economic questions.

At the moment of his death, the problems of the war were his greatest interest. He had devoted all the time that he could spare for the better part of a year to the work of the food administration and other war boards and had just completed a volume on conservation and regulation during the war. A week before his death he had returned from a trip

to England and to the battle fronts in France and Belgium and brought back with him enthusiastic plans for comprehensive after-war work, both through the University and through energetic advocacy of the plan of a League of Free Nations to prevent future wars. Among his associates it is well-known that he realized the danger of German aggression long before it was realized by the public of his section of the country and was eager to see the overthrow of the German military autocracy. When America entered the war, he was full of enthusiasm over what he considered the great, and almost holy, enterprise that the nation had undertaken. And under his guidance the University threw all of its energies and endeavors into a wide range of war activities.

But, now that he is gone, the memory that remains with his colleagues is not alone the recollection of his works, but a simple and affectionate memory for the man himself—an intimate personal regard, shared by all who knew him—students, academic colleagues, field associates—such as is left by few public men. The loss to his friends was not so much a public loss as a personal loss to every one who has ever known or worked with President Van Hise. The tributes written by his colleagues and the great men of his State were not alone eulogies of his great works but expressions of personal sorrow. Among his former students, many of whom are now leading geological or mining men, the inspirational quality of his teaching developed a personal affection that has bound them to him since they left the college halls.

NEW ENTRANCE TESTS FOR COLUMBIA UNIVERSITY

The Faculty of Columbia College, the undergraduate department of Columbia University, on Jan 20, voted to abolish the old-style examination for admission and substitute psychology tests to measure the student's intelligence, rather than his learning. The tests will be similar to those applied to applicants for the Students' Army Training Corps and will be used for the academic year beginning next September.

In the requirements for admission to Columbia College are included the applicant's health record, his character and promise of development, and his school record. The most radical departure is the entire doing away with the old-style examinations that were given to establish the applicant's knowledge of the subjects required for admission to college. This will be covered by his school record, and the psychological tests will demonstrate whether he is qualified to continue his schooling. The tests will be changed each year.

CALIFORNIA MINERAL PRODUCTION IN 1918

The statistical division of the State Mining Bureau estimates the mineral production of California for the year 1918, just closed, at a total of approximately \$191,100,000. The increased value over the 1917 total of \$161,202,962 is due mainly to the very greatly enhanced prices of all grades of crude oil, coupled with an increase of approximately 5,000,000 barrels in quantity. Reports indicate a decrease of nearly \$3,000,000 in gold output, and considerable decreases also for lead and zinc. Copper, apparently, increased slightly in quantity but decreased in value. Quicksilver dropped off about 2000 flasks in quantity, but with a higher price per flask, so that the total value of \$2,310,000 showed a relatively smaller loss.

LIBRARY

American Society of Civil Engineers
American Institute of Electrical Engineers
American Society of Mechanical Engineers
American Institute of Mining Engineers
United Engineering Society
Harrison W. Craver, Director

The Library of the above-named Societies is open from 9 A. M. to 10 P. M. except on holidays. It contains about 70,000 volumes and 90,000 pamphlets, including sets of technical periodicals and publications of scientific and technical societies.

Members of the Institute, with few exceptions, are forced to spend a portion of their time in localities isolated from sources of information. To these the Library, through its Library Service Bureau, can render valuable service through correspondence; letters requesting information will receive especial attention. The Library is prepared to furnish references and photographic copies of articles on mining and metallurgical subjects; to determine the existence of mining maps, and to furnish general information on the geology and mineral resources of all countries.

All communications should be made as definite as possible so that the information received may be what is desired and not include collateral matter which may not be of interest. The time spent in searching for such collateral matter will be saved, and the information will be sent more promptly and in more usable shape.

Library Accessions

American Chamber of Commerce in China. Yearbook, 1918. (Gift of American Chamber of Commerce in China.)

Americanization in Delaware. A state policy initiated by Delaware State Council of Defense. (Gift of Council.)

American Library Annual. 1917–18. New York, 1918.

American Library Institute. Papers and Proceedings, 1917. Chicago, 1918. (Gift of American Library Institute.)

American Society of Mechanical Engineers. Transactions, Vol. 39. 1917. (Gift of Society.)

American Society for Testing Materials. Proceedings of Annual Meeting. 21, 1918. Vol. 18, Pt. 1–2.

Cancellation of Government War Contracts. By William B. King. 1918. (Gift of author.)

Carnegie Endowment for International Peace. Preliminary Economic Studies of the War. No. 6. Effects of the War upon Insurance with Special Reference to the Substitution of Insurance for Pensions. By William F. Gephart. New York, 1918. No. 7. The Financial History of Great Britain, 1914–1918. By Frank L. McVey. New York, 1916. (Gift of Carnegie Endowment for International Peace.)

Cochrane Engineering Bulletin. No. 20. The Scientific Treatment of Boiler Feed Water. 1917. (Gift of Harrison Safety Boiler Works.)

Combinazioni Chimiche fra Metalli. By Michele Giua and Clara Giua-Lollini. Milano, 1917.

DIE GEISTIGEN MITTEL DES TECHNISCHEN FORTSCHRITTES IN DEN VEREINIGTEN STAATEN VON AMERIKA. Bericht über eine im Auftrage des Vereines deutscher Ingenieure im Herbst 1912 durchgeführte Studienreise. Von Conrad Matschoss. Berlin, 1913. (Gift of American Society of Mechanical Engineers.)
DIESEL ENGINE DESIGN. By E. Mortimer Rose. Manchester, Eng. 1917.
DYNAMIC HEATING OF AIR AS A CAUSE OF HOT VOLCANIC BLASTS. By G. N. Cole. Reprint from Monthly Weather Review, Oct., 1918. (Gift of author.)
ENGINEER'S REPORT ON THE BLUE RIVER PLACER MINES, SUMMIT COUNTY, COLORADO. Breckenridge and Denver, Mar. 18, 1912. By Thomas Albert Brown. (Gift of author.)
ENGINEERING FACTS AND FIGURES FOR 1863. An Annual Register of Progress in Mechanical Engineering and Construction. Edited by Andrew Betts Brown. London, 1864.
FIFTEEN SERMONS PREACHED ON VARIOUS IMPORTANT SUBJECTS. By George Whitefield. Glasgow, 1792.
FUEL FACTS. 2d Ed. Information for Consumers and Savers of Fuel. Published by U. S. Fuel Administration. Washington, December, 1918. (Gift of U. S. Fuel Administration.)
GREAT BRITAIN. Mines and Quarries. General Report with Statistics, for 1917, by the Chief Inspector of Mines. Parts 1–3. London, 1918. (Gift of Under Secretary of State, Great Britain.)
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LEGISLACION DE MINAS DE CHILE. Código, Leyes, Reglamentos y Disposiciones Vigentes. Preparada por Fabio Castro Garin. Santiago de Chile, 1918. (Gift of author.)
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NOTES PROVENÇALES. Revue Trimestrielle des Travaux du Dr. Adrien Guébhard. Nos. 1–5. Aug., 1917–Aug., 1918. Paris. (Gift of Dr. Adrien Guébhard.)
OIL FIELDS OF TEXAS. By F. Julius Fohs. (Chart.) (Gift of American Institute of Mining Engineers.)
OIL SAND HORIZONS OF TEXAS. By F. Julius Fohs. (Chart.) (Gift of American Institute of Mining Engineers.)
ON THE MOTION OF POINTS CONSTRAINED AND RESISTED AND ON THE MOTION OF A RIGID BODY. The Second Part of a new Edition of a Treatise on Dynamics. By William Whewell. Cambridge, 1834.
PENNSYLVANIA. Bureau of Standards. Annual Report. 8th, 1918.
PENNSYLVANIA. Dept. of Labor and Industry. Annual Report of the Commissioner of Labor and Industry. 3d, 1915. Part 1.
PENNSYLVANIA. Workmen's Compensation Board. Decisions for 1917.
SHERWIN'S MATHEMATICAL TABLES. 3d Ed., carefully revised and corrected by William Gardiner. London, 1742. (Gift of W. Brokaw Bamford.)
SOME POSTAL ECONOMIES. By Charles Johnson Post and Jesse H. Neal. New York, 1918. (Gift of Publishers' Advisory Board.)
SOUTH DAKOTA SCHOOL OF MINES. Bulletin No. 12. The Occurrence, Chemistry, Metallurgy and Uses of Tungsten with special reference to the Black Hills of South Dakota. By J. J. Runner and M. L. Hartmann. Including a Bibliography of Tungsten by M. L. Hartmann. 1918. (Gift of South Dakota School of Mines.)
TECHNICAL HANDBOOK OF OILS, FATS AND WAXES. By Percival J. Fryer and Frank E. Weston. Vol. 2. Practical and Analytical. Cambridge, Eng., 1918.
THE IRONMONGER DIARY, 1919. London, 1918. (Gift of the Ironmonger.)
THE PROTECTION OF METALS FROM OXIDATION AT HIGH TEMPERATURES. By W. E. Ruder. Vol. 1. 1918. (Gift of Diamond Power Specialty Co.)
THE SCIENCE OF BURNING LIQUID FUEL. A Practical Book for Practical Men. By William Newton Best. 1913. (Gift of author.)
TREATISE ON MECHANICS. By Captain Henry Kater and Rev. Dionysius Lardner. London, 1830. (Gift of Reginald Pelham Bolton.)

UNIVERSITÉ DE LIÉGE. Overture Solennelle des Cours le 21 Octobre 1902. Discours de M. le Recteur V. Dwelshauvers-Dery sur La Machine a Vapeur Moderne. Liége, 1902. (Gift of American Society of Mechanical Engineers.)

Book Notices

Unless otherwise specified, books in this list have been presented by the publishers. The Institute does not assume responsibility for any statements made; these are taken from the preface or the text of the book, unless otherwise noted.

AMERICAN METHODS IN FOREIGN TRADE. A Guide to Export Selling Policy. By George C. Vedder. 1st edition. N. Y., McGraw-Hill Book Co., Inc.; Lond., Hill Publishing Co., Ltd., 1919. 204 pp., 8 × 6 in., cloth, $2.

The author believes in the soundness of the distinctively American methods of developing an export trade that have hitherto been adopted by our most efficient world traders. He attempts to explain how these firms have achieved success and to outline the proper policy for those interested in entering foreign markets.

THE FUNDAMENTAL EQUATIONS OF DYNAMICS AND ITS MAIN COÖRDINATE SYSTEMS VECTORIALLY TREATED AND ILLUSTRATED FROM RIGID DYNAMICS. By Frederick Slate, Berkeley University of California Press, 1918. 233 pp., 8 × 6 in., cloth, $2.

The author feels that the extensiveness of the field of dynamics has necessitated such compression in the general surveys of its principles that the usual treatment leans too heavily on mathematics. His desire has been to prepare a supplement that will direct attention to the physical aspects and to experimental reasoning by offering a flexible continuation of an elementary stage with unsettled achievement. The book forms Part II of "Principles of Mechanics." (Part I, Macmillan Co., 1900.)

A HANDBOOK OF PHYSICS MEASUREMENTS. Vol. I. Fundamental Measurements, Properties of Matter, and Optics. Vol. II. Vibratory Motion, Sound, Heat, Electricity and Magnetism. By Ervin S. Ferry, in collaboration with O. W. Silvey, G. W. Sherman, Jr., and D. C. Duncan. 1st edition. N. Y., John Wiley & Sons, Inc.; Lond., Chapman and Hall, Ltd., 1918, 251 + 233 pp., illus., tab., 8 × 5 in., cloth, $2 a volume.

The aim is to furnish a self-contained manual of the theory and manipulation of those measurements in physics that bear most directly upon work in other departments of study and upon a future professional career. The experiments have been selected with regard to the particular determinations now demanded by science and industry and so grouped as to segregate those of value for students of the various branches of engineering.

PRACTICAL OIL GEOLOGY. The Application of Geology to Oil Field Problems. By Dorsey Hager. 3d edition. N. Y., McGraw-Hill Book Co., Inc.; Lond., Hill Pub. Co., Ltd., 1919. 253 pp., 126 illus., 37 tab., 7 × 5 in., flexible cloth, $2.50.

The author has aimed to provide a clear, concise, practical work on the occurrence of oil and its geology, based on American practice. The present edition, the third in four years, has been thoroughly revised, enlarged, and reset.

STEAM ENGINES. Prepared in the Extension Division of the University of Wisconsin by E. M. Shealy. (Engineering Education Series.) 1st edition. N. Y., McGraw-Hill Book Co., Inc.; Lond., Hill Publishing Co., Ltd., 1919. 290 pp., 173 illus., 9 × 6 in., cloth, $2.50.

This is the third of a series of three text-books of steam engineering, prepared for correspondence students in the University of Wisconsin Extension Division. The aim in this volume is to teach the fundamental principles underlying the operation of the steam engine, in as simple and non-mathematical a manner as possible. Particular attention is given to valve gears.

THE THEORY OF ELECTRICITY. By G. H. Livens. Cambridge, Eng. The University Press, 1918. 717 pp., 11 × 7 in., cloth, $8.25. (Gift of G. P. Putnam's Sons.)

Dissatisfaction with the treatment of this subject in standard text-books leads the author to offer this work as a general text-book on the mathematical aspects of modern electrical theory in which an attempt is made to present the complete subject in a consistent form.

Although his exposition is essentially a mathematical one, much of the purely analytical mathematics usually associated with the subject has been omitted. However, particular attention has been given to the rigorous formulation of underlying physical principles and to their translation into a mathematical theory. The dynamical aspects of the subject have been specially emphasized throughout.

MEMBERSHIP

NEW MEMBERS

The following list comprises the names of those persons who became members during the period Jan. 10, 1919, to Feb. 10, 1919.

ADAMS, FRANCIS SPEARMAN, Supt., Power Dept., Anaconda Copper Min. Co., Anaconda, Mont.
ALDERSON, G. E., Min. & Met. Engr. ....1317 Sloane Ave., Lakewood, Ohio.
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BROPHY, OSCAR, Met. ....1523 S. Broad St., Philadelphia, Pa.
BUTTRAM, FRANK, Chief Geol., Fortuna Oil Co., 424 Liberty National Bank Bldg., Oklahoma City, Okla.
COCHRAN, R. B., Mine Supt., The Teziutlan Copper Co., Aire Libre, Puebla, Mexico.
CONNAR, T. C., Civ. & Min. Engr. & Geol.; Chief Engr., Zanesville Coal Co., Zanesville, Ohio.
DAUE, E. O. ....Capt., Co. A, 212th Engineers, Camp Devens, Mass.
FOLEY, CHARLES B., Electro-Met., Martin Rockwell Corpn., 347 Madison Ave., New York, N. Y.
HOSFORD, WILLIAM F., Asst. Tech. Supt., Western Electric Co., Inc., Hawthorne Station, Chicago, Ill.
HOSTER, M. T., Supt., French Creek Mines, E. & G. Brooke Iron Co., St. Peters, Pa.
KAWASAKI, SHIGETARO, Chief Geol., Geological Survey of Chosen, Government General of Chosen, Keijo, Korea.
MACCULLOCH, JOHN ALEXANDER, Gen'l Supt., Vinegar Hill Zinc Co., Platteville, Wis.
MCKAY, H. S., Supt., Democrata Mine, Cananea Sonora Copper Co., Cananea, Sonora, Mexico.
MCKINNEY, PAUL E., Chem. & Met., U. S. Naval Gun Factory, Washington, D. C.
MACE, CLEMENT H., Mgr., Technical Dept., Business Men's Clearing House, 206 Chamber of Commerce, Denver, Colo.
PLANK, WILLIAM B., District Min. Engr., U. S. Bureau of Mines, West End, Birmingham, Ala.
RICHARDS, RALPH W., Pet. Geol., Petroleum Exploration Co., Inc., 1830 16th St., N. W., Washington, D. C.
SILVERMAN, ALEXANDER, Active Head, School of Chemistry, Univ. of Pittsburgh, Pittsburgh, Pa.
SNYDER, HERMAN L., Plant Foreman, New Cornelia Copper Co., Box 273, Ajo, Pima Co., Ariz.
WEISSBACH, WALTER W., Shift Boss, Arizona Binghamton Copper Co., Stoddard, Ariz.
WESTGATE, LEWIS G. ....Prof. of Geol., Ohio Wesleyan Univ., Delaware, Ohio.
WILLIAMS, J. WARD, Mine Supt., Cia Minerales y Metales, S. A., Ojuela, Durango, Mexico.

Associates

ATKINSON, H. E. ....Atkinson Co., 575 Lyell Ave., Rochester, N. Y.
BARTHOLOMEW, J. N. ....Supt., Sayre Stamping Co., Lockhart Bldg., Sayre, Pa.
BOON, E. E., Act. Mgr., Min. Section, Industrial Sales Dept., Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.
CRUM, HARRY EDWIN, Oil Geol., Central Oil Syndicate, First National Bank Bldg., Denver, Colo.
CURRAN, M. D., Supt., By-Product Coke Plant, The Toledo Furnace Co., Toledo, Ohio.
HALFACRE, GEORGE F., Investigator, Spelter Dept., New Jersey Zinc Co. (of Pa.), Palmerton, Pa.
HARVEY, HARRY D., Pres. & Treas. The Monarch Engrg. & Mfg. Co., 1206 American Bldg., Baltimore, Md.

Horne, Caleb Lee, Combustion Engr., Air Nitrates Corpn., Muscle Shoals, Ala.
Kosicki, Witold..........Mass. Institute of Technology, Cambridge, Mass.
Noon, Thomas H...............1215 N. Nevada Ave., Colorado Springs, Colo.
Salter, James P...............Foundry Supt., Ohio Brass Co., Mansfield, Ohio.
Schmutz, G. L., Min. Engr., Moctezuma Copper Co., Pilares de Nacozari, Sonora, Mexico.
Stahl, George A., Sec'y & Gen'l Mgr., The Vindicator Cons. Gold Min. Co., 603 Symes Bldg., Denver, Colo.
Weber, William G., Mgr., Whipple & Choate, 459 Iranistan Ave., Bridgeport, Conn.
Wheeler, Arthur A., Met., The Barkus & Johnston Co., Casapalea, Peru, S. A.

Junior Associates

Boatright, Byron B.........Student, Colorado School of Mines, Golden, Colo.
Fleming, George G.....Student, Mass. Institute of Technology, Cambridge, Mass.
Hedding, Joseph N.........Student, Pennsylvania State College, State College, Pa.
O'Rourke, Edward V.............Student, Ohio State University, Columbus, Ohio.
Owings, C. Watson........Student, Pennsylvania State College, State College, Pa.
Sefing, Frederic G...........Student, Lehigh University, So. Bethlehem, Pa.
Surfluh, John S...........Student, Colorado School of Mines, Golden, Colo.

Change of Status

Rosenblatt, Girard B.........1212 Walker Bank Bldg., Salt Lake City, Utah.

Total Membership, Feb. 10, 1919............................7202

Change of Address of Members

The following changes of address of members have been received at the Secretary's office during the period Jan. 10, 1919, to Feb. 10, 1919.

This list together with the list published in Bulletins No. 133 to 146, January, 1918, to February, 1919, and the foregoing list of new members, therefore, supplements the annual list of members corrected to Jan. 1, 1918, and brings it up to the date of Feb. 10, 1919.

Adams, C. W., Jr., American Smelt. & Refin. Co., McCormick Bank Bldg., Salt Lake City, Utah.
Adkins, H. S.......Asst. Gen'l Mgr., First Creek Coal Co., Blue Diamond, Ky.
Alden, Herbert W.....Vice-pres., The Timken-Detroit Axle Co., Detroit, Mich.
Allen, Arthur P..................................Box 100, Miami, Ariz.
Allen, Carl A.....U. S. Bureau of Mines, 446 Capitol Bldg., Salt Lake City, Utah.
Alling, Mark N..........................Angels Camp, Sierra Co., Cal.
Ambler, Harry A.....Capt., 30th Inf., General Hospital No. 28, Ft. Sheridan, Ill.
Andrews, Clarence W., Open Hearth Dept., American Steel Foundries, Alliance, Ohio.
Arozena, De Joe........Lieut., 107 Engrs., American P. O. 734, A. E. F., France.
Baker, Harry A.........Capt., Chemical Warfare Section, Camp Kendrick, N. J.
Baker, Hamilton W., Baker & Gaebelein, Suite 404, 185 Devonshire St., Boston, Mass.
Ballenberg, Adolf G......................4754 Greenwood Ave., Chicago, Ill.
Barker, E. E...........Supt., Cerro de Pasco Copper Corpn., Morococha, Peru.
Barnes, Dr. Francis M., Jr..............University Club Bldg., St. Louis, Mo.
Barth, Carl G., Jr.........................244 Larkin St., Buffalo, N. Y.
Bartlett, J. H.....................2116 Confederate Place, Louisville, Ky.
Batcheller, J. H.........................287 Walnut St., Brookline, Mass.
Batten, H. L......................Bank of Montreal, Victoria, B. C., Canada.
Baumann, Henry N., Jr..................................Chichagof, Alaska.
Beers, Albert D., Ore & Fuel Buyer, New Jersey Zinc Co., 160 Front St., New York, N. Y.
Behre, Henry A..........................840 Park Ave., New York, N. Y.
Bentley, Robert...................814 Stambaugh Bldg., Youngstown, Ohio.
Berolzheimer, D. D..............86 Prospect Park West, Brooklyn, N. Y.

BLAIR, ALBERT E.........................3a de los Heroes 45, Mexico, D. F.
BLAKESLEE, FRANK A..........................229 27th St., Milwaukee, Wis.
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BRADEN, WILLIAM, Min. Engr...................42 Broadway, New York, N. Y.
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BRADLEY, D. H., JR..................................Box 93, Prescott, Ariz.
BROWN, PRENTICE FARRAR........The Colorado School of Mines, Golden, Colo.
BROWNE, KENNETH C....................Box 196, Creighton Mine, Ont., Canada.
BRUGGER, MELVIN.........................Columbus State Bank, Columbus, Neb.
BRUNTON, FREDERIC K., Met., Phelps-Dodge Corpn., Copper Queen Branch, Douglas, Ariz.
BURFORD, S. W., Capt., Ordnance Supply Div., 131 Dennison Ave., Davenport, Iowa.
BURGREN, ARTHUR W., American Smelt. & Ref. Co., Matehuala, S. L. P., Mexico.
BURKMAN, JOHN M. F., Chief. Engr., Compania de Santa Gertrudis, S. A., Apartado 1, Pachuca, Hidalgo, Mexico.
BURNS, WILLIAM, Santa Fe Gold & Copper Min. Co., Box 367, Santa Fe, N. M.
BYER, HENRY E.........................Care Grace Brothers, Calcutta, India.
BYERS, WHEATON B., 2d Lieut., Ord. Dept., U. S. A., Watertown Arsenal, Watertown, Mass.
CANNON, FRANK D., Co. 16, Transportation Corps, 14th Grand Div., Camp G. M. Dodge, A. P. O. 701, American E. F., France.
CARPENTER, ARTHUR H........................Sawpit, San Miguel Co., Colo.
CARON, M. H.................Hoofdbureau Mynwezen, Batavia, Java, N. E. I.
CARROLL, WALTER..................B. F. Goodrich Rubber Co., Akron, Ohio.
CAVANAGH, JOHN L..........................New Glasgow, N. S., Canada.
CAVERS, T. WILLARD......International Nickel Co., Copper Cliff, Ont., Canada.
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COOKE, C. C.....Gen'l Mgr., Suyan Min. Co., P. O. Manbar, Logan Co., W. Va.
COOLIDGE, DONALD J........................411 East 7th St., Tarentum, Pa.
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CRANE, WALTER R.........................Bureau of Mines, Washington, D. C.
CRERAR, GEORGE, Care Compania Metalurgica Mexicana, San Luis Potosi, Mexico.
CROWDUS, JOHN WILLIAM.................222 Mills Bldg., El Paso, Texas.
DAKE, WALTER, M. JR........Gen'l Mgr., Blazon Coal Co., Point of Rocks, Wyo.
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DOENNECKE, HENRY W..............Met., Mineral Point Zinc Co., De Pue, Ill.
DONALD, WILLIAM..................................Bloomingdale, N. J.
DOUGAN, LEE DEWANE.......................Elko Prince Mining Co., Midas, Nev.
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DUDLEY, G. H...................................Box 524, Morenci, Ariz.
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FOURNIER, E. ANTUNES................Apartado 154, Pachuca, Hgo., Mexico.
FOX, WALTER V..........Ward Min. & Mill. Co., Tolland, Gilpin Co., Colo.
FRASER, LEE........................El Paso Smelting Works, El Paso, Texas.
FRIEDRICH, ALFRED K..............Buckeye Coal Co., Nemacolin, Greene Co., Pa.
FRITH, CHARLES WILLIAM..................Tintic Milling Co., Silver City, Utah.
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GROOS, HENRY.........Kentucky Rock Asphalt Co., Sweden, Edmonson Co., Ky.
GUDKOV, VALENTIN JOHN.....................308 Fayette St., Johnstown, Pa.
HARDY, R. A...............................Care Thoma Ranch, Fallon, Nev.
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HEIDENREICH, W. LEE......Lowell Apts., 1984 Park Grove Ave., Los Angeles, Cal.
HEIZER, O. F..Tuolumne, Cal.
HERZ, NATHANIEL...Lead, S Dakota.
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KING, ROWLAND..........C. M. Fassett Co., 209 N. Wall St., Spokane, Wash.
KISHMAN, MAURICE W., Mine Foreman, Inspiration Cons. Copper Co., Inspiration, Ariz.
KLEIN, KARL F........Andes Copper Min. Co., Casilla 230, Antofagasta, Chile.
KNEASS, STRICKLAND, JR., Steam Engr., Youngstown Sheet & Tube Co., Youngstown, Ohio.
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LEY, HENRY A...............................Box 1109, Dallas, Texas.
LILLIE, J. J..........................Horn Silver Mines Co., Frisco, Utah.
LINDSAY, B. R...Louisa, Ky.
LIVINGSTON, IVOR......................................Whitwell, Tenn.
LIVINGSTON, WILLIAM S., JR......The Grasselli Chemical Co., New Market, Tenn.
LORD, J. O..............................525 Jackson St., Gary, Ind.
McKINLAY, WILLIAM B..................506 So. Broadway, Yonkers, N. Y.
McLAINE, W. L..................................Box 1072, Casper, Wyo.
MACNICHOL, A. W....................1456 Fulton St., San Francisco, Cal.
McCRARY, E. W..................................Box 790, Tulsa, Okla.
MACOMB, JOHN DE NAVARRE, Major, Engrs., United States Army, Camp Forest, Ga.
MADGE, W. C.........................Care T. F. Jensen, Anaconda, Mont.
MEGRAW, H. A., Kennedy-Van Saun Mfg. & Engr. Corpn., Room, 1718, 120 Broadway, N. Y.
MELITZER, SAMUEL..............Lieut., 212th Engineers, Camp Devens, Mass.
MERRICKS, HOMER I., Supt. of Construction, Edmund T. Perkins Engr. Co., Box 119, Pekin, Ill.
MERRY, F. CHARLES., Min. Engr., National Engineering Corpn., 40 Central St., Boston, Mass.
MILLS R. VAN A., Pet. Technologist, U. S. Bureau of Mines, 506 Custom House, San Francisco, Cal.
MIZEL, MAYNARD..........................1516 55th St., Brooklyn, N. Y.
MOORE, EDWARD W.......Major, Quartermaster Corps, Picron, Little Rock, Ark.
MUDD, SEELEY W.....................2232 Harvard Blvd., Los Angeles, Cal.
MYERS, DESAIX B......Major, 304th Engrs., 79th Division, American E. F., France.
NAGEL, FRANK J., Cia. de Minerales y Metales, S. A., Apt. 251, Monterrey, N. L., Mexico.
NELSON, AXEL S...............................Allenby, B. C., Canada.
NAGEL, H. P., JR........................1517 East 31st Ave., Denver, Colo.
NICHOLLS, J. C., Gen'l Supt., Min. & Smelt. Division, The International Nickel Co. of Canada, Ltd., Copper Cliff, Ont., Canada.
NORTH, ALFRED C...................1551 West 48th Street, Los Angeles, Cal.
NOTT, T. E............................4842 Ellsworth Ave., Pittsburgh, Pa.
OBERG, ANTON C.........................316 Sellwood Bldg., Duluth, Minn.
OLSON, K. E....................Metal & Thermit Corpn., East Chicago, Ind.
OSBORNE, CLARENCE BRISTOL......Geol. Dept., Midwest Refin. Co., Denver, Colo.
PALMER, W. R...Globe, Ariz.
PARTANEN, ISAK, Surveyor-Private, Army Service Corps, Headquarters Detachment, A. P. O. 713, American E. F., France.
PATTERSON, C. T....................334½ W. Pike Street, Canonsburg, Pa.
PELTON, ROGER T...............................Box 937, Bisbee, Ariz.
PERKINS, FRED H.........................16 East Adams Street, Phoenix, Ariz.
PERRINE, IRVING........................Box 376, Hutchinson, Kans.
PETERS, C. B...................................Box 17, Tenafly, N. J.
PETERSON, ORRIN P........Utah-Apex Mining Co., Bingham Canyon, Utah.
PEW, J. EDGAR., Vice-pres., Sun Co., American Exchange National Bank, Dallas, Texas.
PLACE, RICHARD G., Cons. Engr., The Acme Manganese Min. Co., 308 Citizens National Bank Bldg., Hot Springs, Ark.
POMEROY, WILLIAM A......Pomeroy & Hamilton, Kennedy Bldg., Tulsa, Okla.

PRATT, WALLACE E., Chief Geol., Humble Oil & Refin. Co.,
Box 1352, Fort Worth, Texas.
RATTLE, PAUL S., Midvale Steel & Ordnance Co.,
Newhouse Bldg., Salt Lake City, Utah.
REMINGTON, ARTHUR E., Alvarado Min. & Mill. Co., Parral, Chihuahua, Mexico.
RICHELSEN, WALTER A.....................552 Le Claire Ave., Chicago, Ill.
RITTER, ETIENNE A........725 North Cascade Ave., Colorado Springs, Colo.
ROBBINS, PERCY A..................Room 1001, Hobart Bldg., San Francisco, Cal.
ROGERS, JOHN C., International Nickel Co. of Canada, Ltd.,
Copper Cliff, Ont., Canada.
ROYCE, WARD, Capt., Co. B, 27th Engineers, American E. F., Care Postmaster, N. Y.
RUBY, N. H...................................La Colorada, Sonora, Mexico.
SANDBERG, AUGUST..........................R. 1, Box 170, Brawley, Cal.
SARGENT, FITZ WILLIAM, American Brake Shoe & Fdy. Co.,
30 Church St., New York, N. Y.
SCHILLING, GEORGE W................1718 Morgan Place, Hollywood, Cal.
SCHMIDT, W. C......New York & Honduras Min. Co., Sa Juancito, Honduras.
SEARS, STANLEY C..............702 Walker Bank Bldg., Salt Lake City, Utah.
SERVISS, FRED LE VERNE.....Mgr., The Keystone Drafting Co., Golden, Colo.
SEVERY, CLARENCE L........Pemberton & Severy, 803 Mayo Bldg., Tulsa, Okla.
SHEARMAN, WILLIAM H., The New Jersey Zinc Co., 160 Front St., New York, N. Y.
SHELBY, W. W..........American Smelt. & Refin. Co., Charcas, S. L. P., Mexico.
SMITH, F. G..............................108 Field St., Torrington, Conn.
SMITH, HENRY B., New Britain Machine Co., 43 Park Place, New Britain, Conn.
SMITH, HENRY P............................Apartado 55, Guanajnato, Mexico.
SMITH, JAMES W............................30 Sever St., Worcester, Mass.
SPRUANCE, W. C. JR.....................2507 West 17th St., Wilmington, Del.
STALDER, WALTER.........................805 Crocker Bldg., San Francisco, Cal.
STAVER, W. H.............................15 Broad St., New York, N. Y.
STERRETT, DOUGLAS B..................Pierce Mill Road, Washington, D. C.
STOLLER, F. E.......................3426 Bradford Road, Cleveland, Ohio.
STONE, FRANK M., Sgt., Motor Transport Corps, Co. 6, M. R. S. 303,
A. P. O. 772, American E. F., France.
STONE, GEORGE C., The New Jersey Zinc Co., 160 Front St., New York, N. Y.
STUTZ, ERNEST...........................828 Stratford Ave., S. Pasadena, Cal.
TACKMANN, HENRY..........Care Fairview Fluorspar & Lead Co., Golconda, Ill.
TAYLOR, WILLIAM W., Min. & Chem. Engr., Peoples National Bank Bldg.,
Lynchburg, Va.
THOMAS, W. E., Supt., Cia. Minerales y Metales, S. A., Apartado No. 251,
Monterrey, N. L., Mexico.
THOMSON, ALEXANDER T.....Asst. to Pres., Phelps-Dodge Corpn., Douglas, Ariz.
TINSLEY, ROBERT B., Co. C., 605th Engineers, American E. F., Care Postmaster, N. Y.
TREICHLER, H. E.................Texas Gulf Sulphur Co., Matagorda, Texas.
TRISCHKA, CARL, Min. Engr........135 S. Vine St., Richmond Hill, L. I., N. Y.
UDE, EDGAR......Co. L, 355th Infantry, American E. F., A. P. O. 761, France.
VAN VALKENBURGH, R. D.............................Box 353, Scranton, Pa.
VEATCH, A. C................19 Grosvenor Gardens, London, S. W. 1, England.
WALTER, RAYMOND A.....................710 North 5th Street, Reading, Pa.
WALZ, ANDREW, Min. Engr.......................60 Broadway, New York, N. Y.
WARD, HOWARD R., Federal Board for Vocational Education,
317 Railway Exchange Bldg., Denver, Colo.
WARREN, S. POWER, Experimental Flotation Work,
605 Mercantile Bldg., Denver, Colo.
WARRINER, R. C..................Room 2123, 120 Broadway, New York, N. Y.
WELCH, DANIEL A..........................42 Broadway, New York, N. Y.
WELSH, H. LEE...................................Box 301, Anaconda, Mont.
WHITE, CHARLES H....................317 Hobart Bldg., San Francisco, Cal.
WICKES, L. WEBSTER, Major, Headquarters, 212th Engineers, Camp Devens, Mass.
WILFLEY, C. R....................................Box 119, Denver, Colo.
WISE, ALFRED L.........................28 East 83d St., New York, N. Y.
WONG, Y. C.............Chem., American Smelt. & Refin. Co., Omaha, Neb.
WYLER, JOSEPH A.............................1213 3d St., Catasaqua, Pa.
YATES, A., Royal School of Mines, Prince Consort Road,
South Kensington, London, S. W. 7, England.
YOUNG, WILLIAM G., Cons. Engr. & Min. Engr., West Kentucky
Co-operative Coal Co., 914 S. Alvarado St., Los Angeles, Cal.

MEMBERS' ADDRESSES WANTED

Name.	Last address of Record from which Mail has been returned.
ARMSTRONG, E. W.	Mina Bibilonia, La Libertad, Nicaragua, C. A.
BACON, MAURICE W.	726 Old National Bank Building, Spokane, Wash.
BIRD, FRANK H.	Butler Hotel, Seattle, Wash.
BLANCHARD, RALPH C.	3 Lombard St., London, England.
BREEDING, F. O.	Eden Min. Co., Bluefields, Nicaragua.
DETERT, WILLIAM F.	Jackson, Amador Co., Cal.
HERR, J. CAMPBELL	Box 556, State College, Pa.
HUGHES, WILSON W.	Care Lloyd's Bank, Forrey, Cornwall, England.
HUNTER, CHARLES	Royal Colonial Institute, Northumberland Ave., London, W., England.
HURUM, FREDRIK J. O.	Westmorley Court, Cambridge, Mass.
KAMMERER, CHARLES	Box 412, San Francisco, Cal.
KAY, DAVID NELSON	Ray Cons. Copper Co., Hayden, Ariz.
KING, FRANK E.	Hotel Breslin, New York, N. Y.
KLEESATTEL, RICHARD	911 White Bldg., Seattle, Wash.
KLUGESCHEID, WALTER P.	616 W. 113th St., New York, N. Y.
MENEFEE, ARTHUR B.	Hibernia, N. J.
NELSON, THEOPHILUS L.	Empire Coal Co., Empire, Ala.
STICKNEY, WILLIAM H.	708 N. Center St., Reno, Nev.
TAPLIN, THOMAS J., JR.	16 Lordship Park, London N. 16, England.
TINGLEY, T. W.	Beutree, W. Va.
TREAT, LLOYD B.	Canadian Ingersoll-Rand Co., Bank of Toronto Bldg., Montreal, Canada.
WOO, W. K.	M 70 Sing Kong Li, Minghong Road, Shanghai, China.

NECROLOGY

(See also "Died in Service")

The deaths of the following members were reported to the Secretary's office during the month Jan. 10, 1918, to Feb. 10, 1919.

Date of Election.	Name.	Date of Death.
1919	Collins, George N.	Jan. 19, 1919.
1917	Dennis, A. C.	Dec. 3, 1918.
1916	Ellis, Hubert I.	Jan. 6, 1919.
1914	Fraser, Keith Colt	Dec. 12, 1918.
1918	Galligan, Emmet F.	Jan. 18, 1919.
1915	Henley, A. R.	Nov.—, 1918.
1917	Lavery, H. H.	—— 1918.
1914	McCormick, Alan F.	Dec. 23, 1918.
1917	Noehl, B. F.	—— 1918.
1916	Sauerschnig, Jose	———
1906	Smith, Frank G. D.	Jan. 20, 1919.
1917	Webber, G. E., Jr.	Oct. 26, 1918.

CANDIDATES FOR MEMBERSHIP

APPLICATION FOR MEMBERSHIP.—The Institute desires to extend its privileges to every person to whom it can be of service. On the other hand, it is not desirable that persons should be admitted to membership in classes for which they are not qualified. Members of the Institute can be of great service if they will make a practice of glancing through the list of applicants and promptly notifying the Committee on Membership, or the Secretary of the Institute, of any persons whom they think should not be classified in accordance with the list given.

Applications Lacking Endorsement

Application for membership has been received from Mr. Brink, whose record is given below. This application lacks the necessary number of endorsers, but since this candidate lives at some distance from the headquarters of the Institute, his record is published here in order that any members who are acquainted with him may be advised of the circumstances and may have an opportunity of writing to the Secretary endorsing this candidate.

Member

Cyril Gordon Brink, Transvaal, So. Africa.
Born 1889, Grahamstown, So. Africa. 1900–05, High School. 1906–07, St. Andrews School. 1908–09, Chem., Rhodes Univ., Grahamstown. 1910–15, In Reduction Wks., Norse Gold Mines, Ltd., Johannesburg. 1915–17, Leading Shiftsman, and in chg. of reduction wks., Fairview gold mine, Transvaal Cons. Mines.
Present position—1917 to date: Reduction Officer, Fairview Devonian Montrose Gold Mines, Ltd.

The following persons have been proposed during the period Jan. 10, 1919, to Feb. 10, 1919, for election as members of the Institute. Their names are published for the information of Members and Associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Board of Directors, which has the power of final election.

Members

Peter Albert Ballard, So. Dak.
Proposed by Edward L. Estabrook, C. C. O'Harra, B. C. Yates.
Born 1883, Chicago, Ill. 1906–11, South Dakota School of Mines. 1915–16, New Mexico School of Mines, M. E. 1909–14, Conducted surveying office, Rapid City, So. Dak. 1910–12, County Surveyor. 1914, Mine Surveyor, Rosario mines, San Juancito, Honduras, C. A. 1915, Instructor, surveying, New Mexico School of Mines. 1914–15, Surveyor and Asst. Geol., Norbeck & Nicholson Co., Redfield, So. Dak. 1916–17, Surveyor and Field Mgr., oil fields, Hot Creek, Wyoming. 1917–18, Surveyor and Cons. Pet. Geol., Lusk, Wyoming; also employed by Norbeck & Nicholson Co.
Present position: Field Geol., Midwest Refin. Co., Denver, Colo. and Casper, Wyoming.

August Joseph Barnebl, Jr., Newark, N. J.
Proposed by J. V. N. Dorr, H. N. Spicer, D. S. McAfee.
Born 1883, E. Williamsburg, L. I. 1901–05, Columbia Univ., E. M. 1905–06, Assayer, Bamberger De Lamar Gold Mines Co. 1906, Millman, Tonopah Min. Co. 1907, Assayer, Cananea Cons. Copper Co. 1908–09, Assayer and Surveyor, Salt Lake Copper Co. 1909–10, Leasing same property as above. 1911, Timberman, Tennessee Copper Co. 1912, Supt., Prize Min. Co. 1913–14, Leasing, Salt Lake Copper Co. property. 1915–16, Millman and Assayer, Aurora Cons. Gold Mines Co. 1916–18, Draftsman, Edison Chem. Works and Balbach Smelt. & Refin. Co.
Present position: Mech. Engr., The Dorr Co., New York, N. Y.

Charles William Barry, Idaho Springs, Colo.
Proposed by R. E. Schirmer, James Underhill, D. A. Barry.
Born 1862, Nova Scotia, Canada. Common School; International Correspondence Schools. I. C. S. Spanish Language Course. Prior to 1892, on railroad surveys, and construction work, house carpenter, and joiner work. 1892–1903, On mine and mill buildings, aerial tramways, millwright work and mining. 1903–04, Supt. of min. operations for Big 5 T. O. R. & T. Co., San Juan County, Colo. 1904–11, on constr., remolding and operation of concentration and amalgamating mills, and supt. of mining operations in Mexico and U. S. 1911–18, Supt., The Big 5 Min. Co., Boulder County, Colo.
Present position: Stationary Engr., The Big 5 Min. Co.

Burnie L. Benbow, Cleveland, Ohio.
Proposed by Zay Jeffries, Theron D. Stay, R. H. Allport.
Born 1885, New Castle, Ind. 1908, Electrical Engrg., Purdue Univ., B. S. 1908–09, Locomotive and Equipment Inspector, Penna. R. R.
Present position—1909 to date: Mgr., Cleveland Wire Div., National Lamp Works, General Electric Co.

Eliot Blackwelder, Urbana, Ill.
Proposed by Ralph E. Davis, W. N. Smith, W. O. Hotchkiss.
Born 1880, Chicago, Ill. 1897–1903, Univ. of Chicago, A. B. 1904, Univ. of Chicago, Ph. D. 1901–02, U. S. Geological Survey. 1903–05, Carnegie Institution of Washington. 1906–18, Geol., U. S. Geol. Survey: Asst., Univ. of Chicago. 1905–16, Prof., Univ. of Wisconsin. 1916, Head of Dept., Univ. of Illinois. 1917, Member, Cal. State Pet. Committee. 1919, Acting Prof., Stanford Univ., winter quarter.
Present position: Prof. of Geol., Univ. of Illinois.

Clifford B. Bronson, New York, N. Y.
Proposed by P. H. Dudley, E. G. Grace, Charles E. Dinkey.
Born 1889, Akron, Ohio. 1903–07, Austin High School. 1909, Lewis Prep. 1909–13, Lewis Institute, B. S. in M. E. 1912–13, Instructor and Lab. Asst. in Physics, Lewis Institute Evening School.
Present position—1913 to date: Mech. and Met. Asst. to Dr. P. H. Dudley, Cons. Engr., Rails, Tires and Structural Steel, New York Central Lines.

Earl Hamlin Bunce, Palmerton, Pa.
Proposed by James M. Bonsall, Louis A. Wilson, L. S. Holstein.
Born 1891, Wolcott, N. Y. 1909–13, Cornell Univ., B. C. 1913–17, Met., New Jersey Zinc Co.
Present position—1917 to date: Asst. Chief, Research Division, New Jersey Zinc Co.

Samuel James Burris, Jr., Denver, Colo.
Proposed by J. C. Roberts, M. F. Coolbaugh, I. A. Palmer.
Born 1893, Pueblo, Colo. 1915, Colorad School of Mines, E. M. 1912, Draftsman, Pueblo Found. & Mach. Co., Pueblo, Colo. 1914, Assayer, Incas G. M. & M. Co., La Plata City, Colo. 1915, Shift Boss, Oro Grande Min. Co., Siskiyou City, Cal. 1916, Engr., Valley View Cons. G. Min. Co., Hesperus, Colo. 1916–17, Supt., Incas Gold Min. Co., Hesperus, Colo. 1917–18, Supt., Boston & Arkansas Min. Co., Gillham, Ark. 1918, Officers' Training School, U. S. Naval Academy.
Present position—1918 to date: Ensign (T), U. S. N., Bureau of Construction and Repair, Aircraft Div., Spec. Section.

Demetrius Edward A. Charlton, New York, N. Y.
Proposed by W. R. Ingalls, George J. Young, Arthur W. Allen.
Born 1885, Detroit, Mich. 1901–03, St. John's Military Acad., Delafield, Wis., 1903–10, Michigan College of Mines, E. M. 1905, Instrument-man on constr., Marquette & Southeastern Ry. Co. 1905–07, Levelman, Draftsman, Asst. Min. Engr., Oliver Iron Min. Co., Hibbing & McKinley, Minn. 1908, Asst. Min. Engr., Verona Min. Co., Palatka, Mich. 1909–10, Sampling Dept., Detroit Copper Co., Morenci, Ariz. 1910–11, Assayer, Chief Cons. Min. Co., Eureka, Utah. 1911–12, Min. Engr. and Assayer, Victoria Cons. Min. Co., Eureka, Utah. 1912, Assayer, Chief Cons. Min. Co., Eureka, Utah. 1912–14, Min. Engr., Oliver Iron Min. Co., Virginia, Minn. 1914–17, Safety and Efficiency Engr., O. I. M. Co., Virginia, Minn.
Present position: Editorial Staff, *Engng. & Min. Jnl.*

Otto Lindsay Collier, Mullens, W. Va.
Proposed by Ernest M. Merrill, John Stewart, Thomas H. Clagett.
Born 1880, Uniontown, Pa. 1898, Grad., Uniontown High School. 1899, Grad., Kishiminetas Springs Prep. School. 1899–1900, Cornell Univ. 1900–04, Min. Transitman, Engrg. Dept., H. C. Frick Coke Co., Scottdale, Pa. 1904–07, Min. Transitman, Hogg & Porter, Engrs., Uniontown, Pa. 1907–08, Transitman on Constr. of Govt. coal bunker, Engrg. Dept., San Francisco Bridge Co., San Francisco, Cal. 1908–09, Asst. to Chief, Porcupine Gold Min. Co., Porcupine, Alaska. 1909–13, Chief of party on irrigation and subdivision of lands, Canavan & Mitchell, Cons. Engrs., Victoria, B. C. 1913–15, Charge of mines and municipal work, E. C. Baker Engrg. Co., Uniontown, Pa.
Present position—1915 to date: Res. Engr., charge Mullens Branch, E. M. Merrill Engrg. Co., Beckley and Mullens, W. Va., Sec'y, E. M. Merrill Engrg. Co.

John Newman Davis, Engelmine, Cal.
Proposed by Henry Hanson, Roy H. Elliott, Jules Labarthe.
Born 1884, Dayton, Nev. 1900–04, Carson High School. 1904–08, Nevada School of Mines, B. S. 1912–14, Mill Foreman, Pittsburgh Silver Peak Gold Min. Co., Blair, Nev. 1914–15, Mill Supt. of same Co. 1916–18, Assayer, Flotation Operator and Supt., Engels Copper Min. Co., Engelmine, Cal.
Present position: Mill Supt., Engels Copper Min. Co.

William Rudolph Doell, Benham, Ky.
Proposed by A. C. Oberg, H. I. Pearl, Edward Prosper McCarthy, John Uno Sebenius.
Born 1884, Minneapolis, Minn. 1904–05, School of Mines, Univ. of Minnesota. 1905–06, Asst. Engr., Adams mine, Eveleth, Minn. 1906–07, Engr., Stephens mine, Aurora, Minn. 1907–13, Asst. Engr., Adams District, Oliver Iron Min. Co., Eveleth, Minn. 1913–18, 1st Asst. Chief Engr., Adams District, Oliver Iron Min. Co. 1918, Min. Engr. and Geol., J. F. Wolff.
Present position—1918 to date: Chief Engr., Coke Wks., Wisconsin Steel Co.

Glenn Hall Dukes, Columbus, Ohio.
Proposed by S. B. Belden, F. A. Ray, J. H. Frantz.
Born 1867, Benton Ridge, Ohio. 1884, Grad., High School, Ada, Ohio. 1887, Ohio Northern Univ., B. S. 1887–90, Kramer & Loll, Architects. 1890–92, Draftsman Western Ry. 1894, Asst. Engr., Preliminary R. R. Survey. 1895, Deputy County Surveyor, Northern Ohio. 1899–1902, Asst. Engr., H. V. Ry. 1902–03, Asst. Engr., Buckeye Coal & Ry. Co. 1903–07, Principal Asst. Engr., H. V. Ry. 1907–17, Chief Engr., Sunday Creek Coal Co. and Buckeye Coal & Ry. Co.
Present position: Chief Engr. of above companies.

Bert William Dyer, Washington, D. C.
Proposed by George S. Rice, R. R. Hornor, E. A. Holbrook.
Born 1884, St. Paul, Minn. 1906–09, Montana School of Mines. 1909–10, Univ. of Utah, B. S. 1911, Chainman; 1911–12, Transitman and Engr.; 1912–15, Mine Foreman, Northwestern Improvement Co. 1915, Miner; 1915–16, Sampler; 1916–18, Shift boss, Anaconda Copper Min. Co. 1918–19, Asst. Mine Safety Engr., U. S. Bureau of Mines.
Present position: Min. Engr., U. S. Bureau of Mines.

Charles Ernest Evans, Murray, Utah.
Proposed by W. W. Norton, J. B. McIntosh, A. L. Labbe.
Born 1880, Chicago, Ill. Completed the entire mech. engrg. course of the International Correspondence School. 1903–08, Draftsman, Link Belt Co., of Chicago. 1908–12, Draftsman, Checker and Designer, Stephens Adamson Mfg. Co.
Present position—1912 to date: Chief Draftsman, American Smelt. & Refin. Co., Murray, Utah.

Donald Patton Falconer, Cleveland, Ohio.
Proposed by Daniel Cushing, Roy A. Hunt, H. C. Parmelee.
Born 1883, Warren, Pa. 1898–1901, Warren High School. 1901–05, Univ. of Wisconsin, B. S., C. E. 1905–09, Pennsylvania Railroad; 1905, Office of Chief Engr. Maintenance of Way, Northwest System, Pennsylvania Lines West, Pittsburgh, Pa.; 1905, Charge of Constr., 12-stall Engine House, Mansfield, Ohio. 1906, Returned to Pittsburgh office; 1906, transferred to Office of Engr., Maintenance of Way, Erie &

Ashtabula Div., Pennsylvania Lines West, New Castle, Pa. 1908, Asst. on Engrg. Corps., office of Engr. of Maintenance of Way, Louisville, Ky. 1909, Asst. Engr., Maintenance of Way, New York State Railways, Rochester, N. Y. 1912-18, Engr., Maintenance of Way.

Present position—1918 to date: Sales Agent, Shawinigan Electro-Metals Co., Ltd.

Paul Vance Faragher, Pittsburgh, Pa.

Proposed by Raymond F. Bacon, Oscar E. Harder, Jesse L. Jones.

Born 1888, Sabetha, Kans. 1905–10, Univ. of Kansas. 1910–12, Mass. Inst. of Tech. 1912–13, Univ. of California, A. B. and Ph. D. 1913–18, Asst. Prof., Chemistry, Univ. of Kansas. 1918, Assoc. Prof., Chem., Univ. of Kansas.

Present position: Research Fellow, Mellon Inst., Univ. of Pittsburgh.

Russell Peyton Fitch, Monarch, Wyo.

Proposed by W. D. Waltman, Max W. Ball, Charles T. Lupton.

Born 1887, Montserrat, Mo. 1907, Grad., High School, Warrensburg, Mo. 1908–11, Univ. of Missouri. 1911–12, Missouri School of Mines, Rolla, Mo. 1912, Asst. City Engr., Warrensburg, Mo. 1912–14, City Engr., Warrensburg, Mo. 1915, General Engr. work in southwest Missouri, including municipal engrg., min. engrg. and railroad work, designing, surveying, map drafting, mining.

Present position—1915 to date: Min. Engr., Monarch Coal Min. Co.

Lawford Howard Fry, Burnham, Pa.

Proposed by A. A. Stevenson, Frank D. Carney, Guilliaem Aertsen.

Born 1873, Richmond, Quebec. 1886–90, Bedford Grammar School. 1892, City Guilds of London. 1894–97, Hannover Polytechnikum. 1899–1905, Engr. in sales dept., Baldwin Locomotive Works. 1905–13, European Technical Representative, Baldwin Locomotive Works.

Present position—1913 to date: General Inspector, Standard Steel Works Co., Burnham, Pa.

F. Park Geyer, Ponca City, Okla.

Proposed by Irving Perrine, S. L. Galpin, Frank Buttram.

Born 1891, South Haven, Kans. 1912–16, University of Okla. 1916–17, Instructor on Northwestern State Normal School, Alva, Okla. 1917–18, Geol., Empire Gas & Fuel Co.

Present position: Chief Geol., Masland Refining Co.

Rea Calvin Helm, Worcester, Mass.

Proposed by Edwin H. Peirce, E. S. Moore, Charles P. Turner.

Born 1890, Greene, Pa. 1903–07, Steelton High School, Steelton, Pa. 1909–13, The Pennsylvania State College, S. B., M. E. 1908–09, Clerk, Chief Engrs. Office, The Pennsylvania Steel Co., Steelton, Pa. 1913 to date, Research work, physical laboratory, American Steel & Wire Co., Worcester, Mass.

Present position: Chief of Physical Laboratories.

Oliver P. Hess, Du Bois, Pa.

Proposed by Walter Fahringer, W. S. Ayres, Albert D. Oberly.

Born 1879, Fishing Creek, Pa. 1895, Common School, Pa. 1895–97, High School, Hazelton, Pa. 1898–99, State Normal School, Bloomsburg, Pa. 1899–1901, Public School Teacher, Fishing Creek, Pa. 1901–02, Rodman, New York C. & H. R. R. R. 1902, Rodman, Pittsburgh, Shawmut & Northern R. R.; 1902, Rodman, Wilkes-Barre & Hazelton Ry. 1902–03, Transitman, Raleigh & Western R. R. 1903, Transitman, West Penn. Ry. Co. 1904, Lehigh Valley Coal Co., Wilkes-Barre, Pa. 1904–05, Erie R. R., Transitman. 1905–12, Resident and Asst. Engr., West Penn. Rys. Co. 1912–14, Div. Engr., West Penn. Rys. Co. 1914–18, Gen'l Supt., West Penn. Rys. Co.

Present position—1918 to date: Associated with E. W. Hess, Clearfield and Du Bois, Pa. Civil and Min. Engr.

Robert Scott Hill, Rapid City, So. Dak.

Proposed by C. C. O'Harra, Charles H. Fulton, Frank R. Van Horn.

Born 1884, Easthampton, Mass. 1909–14, So. Dak. School of Mines, B. S., M. E. Summers, laborer in Homestake and other Black Hills mines during school intervals. 1914, Assayer, Bismarck Cons. Mines Co., So. Dak. 1914–15, Roustabout and

Asst. Engr., Socorro M. & M. Co., Mogollon, N. Mex. 1915–18, Engr., Société International Forestière et Minière du Congo, Tshikapa, Kasai, Congo Belge.
Present position: Unattached.

Joseph Leonidas James, Sego, Utah.
Proposed by J. H. McChrystal, J. B. Ambler, B. B. Brewster.
Born 1876, Madisonville, Tenn. 1895, Hamilton Inst., Mendota, Va. 1895–1900, Asst. to Sec'y, and Gen'l Mgr., Stony Creek Lbr. Co. 1900–03, Mine Supt., Seaboard Coal Co. 1904–07, Private engrg. practice in different localities. 1908–09, Asst. Engr. and Supt., Cia Carbonifera de Lampacitos, S. A., Baluarte, Coah., Mexico. 1910, Supt., Rocky Mt. Fuel Co. 1911–16, Constr. Foreman, Electric Bond & Shares Co. 1917, Supt., American Asphalt Assn.
Present position—1918 to date: Gen'l Supt., American Fuel Co. of Utah.

John Alexis Korsookeen, New York, N. Y.
Proposed by Robert S. Botsford, Fedor F. Foss, J. B. Landfield, J. A. Meyerovitch.
Born 1871, Petrograd, Russia. 1881–91, Petrograd Gymnasium. 1891–96, Russian Min. Inst. Russian M. E. 1896–97, Engr. in chg. and Supt., lead mine in No. Caucassus. 1897, Engr. Supt., South Russian blast furnaces. 1897–98, Supervising Engr., Volga Steel Works. 1898–1900, Chief Engr. for making researches (Tin and Naphtha); 1900, Engr. in chief, geol. studies in Ural. 1900–06, Asst. Prof. and Prof. in ore deposits, Russian Min. Inst., Petrograd, Russia; 1903, Mgr., Expeditions to Ichuxtze Peninsula. 1906–17, Min. Advisor, Russian Ministry of Finances. 1912–17, Min. Expert, Ministry of Trade and Commerce. 1917, Member, Scientific Board for Mining in Russia.
Present position: Cons. Engr.

Paul Evlampievitch Kovaloff, New York, N. Y.
Proposed by Robert S. Botsford, Fedor F. Foss, J. B. Landfield, J. A. Meyerovitch.
Born 1876, Jaroslawl, Russia. 1887–95, Jaroslawl Gymnasium. 1895–1900, Russian Min. Inst., Petrograd, Russia. Russian M. E. 1900–03, Asst. Geol., Geological Committee (Russian Geol. Survey). 1904–10, Asst. Prof., Min. Inst., Petrograd, Russia. 1910–15, Mgr., Section of Gold Min., Min. Dept., Ministry of Trade and Industry. 1915–17, Vice Director, Min. Dept., Ministry of Trade and Industry.
Present position: Cons. Engr.

Frederick Kruse, New York, N. Y.
Proposed by James F. Kemp, Charles P. Berkey, Robert Peele.
Born 1880, Central City, Colo. 1888–96, Central City Public Schools. 1896–900, Central City High School. 1901–03, Univ. of Denver, Colo. 1903–07, Columbia Univ., School of Mines, E. M. 1907–09, Private instruction in engrg. to Kingon Gould. 1910–12, Statistician to Pres., Missouri Pac. Ry. 1912–14, Sec'y to 'res., Cons. Coal Co. of St. Louis; Sec'y to Pres., The Western Coal & Min. Co. 915–16, Pres., Furlough Dev. Co., Maricopa, Ariz. 1914 to date, Asst. to Pres., nd Director, Cons. Coal Co. of St. Louis. As Asst. to Pres., have had responsible harge of policy and general operations of company's mines in Ill. 1910–18, Have cted as Min. and Cons. Engr. for George J. Gould, and have examined and reported n numerous coal and metalliferous properties.
Present position: Asst. to Pres., and Director, Cons. Coal Co. of St. Louis.

Frederic Henry Lahee, Dallas, Tex.
Proposed by Jerome A. Chevalier, C. L. Severy, W. R. Hamilton.
Born 1884, Hingham, Mass. 1903, Brookline High School. 1903–07, Harvard ollege, A. B. 1907–11, Harvard Graduate School, A. M. and Ph. D. 1906–09, sst. in Geol. 1909–12, Instructor in Geol., Harvard College. 1908–18, Instructor . Geol., Wellesley College. 1912–14, Instructor in Geol.; 1914–18, Asst. Prof., lass. Inst. of Tech. 1913, summer, Geologic Aid, U. S. Geological Survey, Sierra evada. 1916, summer, Head of Camp, Harvard Summer School in Geol. 1917, ummer, Chief of party, petroleum investigations in W. Va. and Ohio. 1918, summer, hief of party, petroleum investigations in North Texas for Sun Co.
Present position: Assoc. Geol., Sun Co.

Frank Pinney Longmire, British Isles.
Proposed by R. E. Palmer, Frank Merricks, T. E. Mitchell.
Born 1882, Moresby Nr. Whitehaven. 1899–06, Student apprentice, Workington Hein Iron, Steel & Coal Co., Ltd., Workington, Cumberland, Eng.; Patternmaker with same company; Drawing-office work in connection with mines, Kaslin Mines, B. Fayle & Co., Dorset; Lab. work with blast and Siemens furnaces; 2 yr. as asst. 1906–09, Engr. Assayer, Messers. Harry Dougall & Co. 1909–10, Asst. Mgr., Empresa H. Borner, La Lima mine, El Pedroso Prov. de Sevilla, Spain. 1910–14, The Rio Tinto Co. Ltd; Rio Tinto, Spain. 1914, Royal Engineers.
Present position: Capt., Royal Engineers.

Arthur Byron Maxwell, Chico, Tex.
Proposed by A. D. Sproat, Marion L. Thomas, A. W. Hahn.
Born 1882, Chico, Tex. 1909–12, Missouri School of Mines. 1904–05, Miner, Cananea Cons. Copper Co., Cananea, Son., Mexico. 1905–06, Cyanide Dept., Esperanza Min. Co., El Oro, Mexico. 1907, Shift Boss, cyanide plant, Guanajuato Cons. M. & M. Co., Guanajuato, Mexico. 1907–08, Cyanide Dept., El Oro Min. & Railway Co., El Oro, Mexico. 1908–09, Mill and Cyanide Shift Boss, Esperanza Min. Co., El Oro, Mexico. 1909, Cyanide Shift Boss, Ventanas Min. & Exploration Co., Ventanas, Dgo., Mexico. 1910, Assayer Chem., Reforma Min. & Mill. Co., Campo Morado Guer., Mexico. 1911, Mill and cyanide Shift Boss, Peregrina Gold Min. Co., Guanajuato, Mexico. 1912, Short jobs, mine examination and surveying. 1912–13, Mine Supt., Neispa Copper Co., Manzanillo, Mexico. 1914–16, Experimental plant and mill sampling, Miami Copper Co., Miami, Ariz. 1916–17, Chem. and Surveyor, Santa Fe Gold & Copper Co., San Pedro, N. Mex. 1917, Mill and Cyanide Supt., Dayton Placer Recovery Corpn., Dayton, Nev. 1918, Mill Supt., National Pyrite & Copper Co., Pyriton, Ala. 1918, Enlisted in U. S. Army.
Present position: Disengaged.

Charles R. Meissner, Jersey City, N. J.
Proposed by Carl A. Meissner, J. A. Ruilabo, J. H. Gray.
Born 1889, Sterlington, N. Y. 1912, Grad., Cornell Univ., C. E. 1912, Min. Engr., Oliver Iron Min. Co., Eveleth, Minn. 1914–16, Operator and foreman, various positions, blast furnace and coke plants, Inland Steel Co., Indiana Harbor, Ind. 1917, Asst. Supt., coke plant, Belle Iron Works, Steubenville, Ohio.
Present position—1918 to date: Experimental Engr., The Koppers Co., Pittsburgh, Pa.

Everett C. Parker, Ponca City, Okla.
Proposed by Irving Perrine, S. L. Galpin, Frank Buttram.
Born 1891, Hennessey, Okla. 1910–14, Major, Geol., Oklahoma Univ., A. B. 1914–16, Instructor in science and math., Kiefer High School. 1916–17, Field Geol., Marland Oil Co. 1917–18, Resident Subsurface Geol., Empire Gas & Fuel Co., El Dorado, Kans. 1918, Coast Artillery School, Fort Monroe, Va.
Present position—1918 to date: Chief of Subsurface, Geol., Marland Refin. Co.

Walter F. Rittman, Pittsburgh, Pa.
Proposed by Van H. Manning, George S. Rice, C. B. Dutton.
Born 1883, Sandusky, Ohio. Swarthmore College and Columbia Univ., C. E., Ph. D. 1908–10, Chem., U. G. I., Philadelphia, Pa. 1910–12, Cons. Chem. Engr., Philadelphia, Pa.
Present position—1912 to date: Chem. Engr. of own Company, also Cons. Chem. Engr., U. S. Bureau of Mines.

Edgar Wilson Smith, Washington, D. C.
Proposed by D. Cole, R. C. Nowland, Frank H. Probert, John Alden Grimes, W. R. Appleby.
Born 1882, Minneapolis, Minn. 1902, Minneapolis High School. 1902–07, Univ. of Minnesota, E. M. 1905, summer, Mucker and Trammer, Calumet & Arizona Min Co., Bisbee, Ariz. 1906, summer, Miner, Machineman under ground, Asst. Surveyor, Old Jordan and Highland Boy mines, Bingham, Utah. 1907–09, Miner and Timberman Quartette Min. Co., Searchlight, Nev. 1909–10, Supt., Arizona Mascot mine, Crown King, Lake Superior & Nevada Dev. Co. 1911–15, Supt. and Engr., Mammoth mine, Goldfield, Ariz. 1911–15, U. S. Mineral Surveyor for Arizona. 1915 to date, Member, Bissell & Smith, Westville, Cal.
Present position—1917 to date: 1st Lieut., Engrs., U. S. A.

Silas Clifford Stathers, Shreveport, La.
Proposed by Alan Bruyere, A. Faison Dixon, H. B. Goodrich.
Born 1871, Alma, W. Va. West Virginia Univ., B. S., C. E. 1895–97, City Engrs. Office, Wheeling, W. Va. 1897, South Penn. Oil Co., W. Va. 1901–03, Gen'l Engr., coal field, W. Va. 1903–05, Min. Engr., J. H. Weaver, Philadelphia, Pa. 1906–08, Gen'l Engrg. Geol., A. Cummins. Purchasing coal for U. S. Steel Corpn. 1911–13, Geol., American Pet. Co. 1913, Geol., South Penn. Oil Co. 1914, Geol., Hope Gas Co. 1914–17, Geol., Romano-Americano Co.
Present position—1917 to date: Chief Geol., Standard Oil Co. of La.

Randall Cross Stewart, Shreveport, La.
Proposed by Charles R. Eckes, Alan Bruyere, Eugene W. Shaw.
Born 1881, High Rock, Pa. Stewartstown College, Stewartstown, Pa. 1907–18, Asst. Gen'l Supt. and in charge of field work, Producing Dept., The Texas Co.
Present position: Asst. Gen'l Supt., Louisiana Division, The Texas Co.

Rupert Octavius Stokes, Surrey, England.
Proposed by J. Thame, J. Mitchell Roberts, William Russell.
Born 1887, Woodford Essex, England. Educated at Sir George Mononx Grammar School, Walthamstow, England. 1902, Pupil; 1905, Draftsman, The East Ferry Road Engrg. Works Co., Ltd., London, E. 1907, Went to Canada.; 1907, Intercolonial Ry. 1908, Asst. to Chief Draftsman, John Inglis Co., Toronto. 1910, Draftsman; 1912, Chief Draftsman and Engr., The Wilfley Co., London. 1913, In charge of erection of concentrating plant in Norway, designing and concentrating plants in England. 1916, Joined H. M. Forces as Engr., Lt. Royal Indian Marine.
Present position: Asst. Engr. to Charles Butters & Co., London.

D. Dee Teets, Jr., Buckhannon, W. Va.
Proposed by W. L. Cumings, Hubert Merryweather, C. A. Buck.
Born 1875, Buckhannon, W. Va. 1893–99, W. Va. Conference Seminary. 1899–1905, West Virginia Univ. 1904, W. Va. Wesleyan College. 1902–03, Transitman, Belington & Northern R. R. Co. 1903–04, Transitman, and Asst. Res. Engr. on revised location and const. for the Little Kanawha R. R. Co. 1904–05, Special engrg. work in W. Va. Univ. 1905, Precise Levelman, U. S. Geological Survey. 1905–06, Pile Recorder, Appalachian Colo. R. R. Co. 1906, Precise Levelman, U. S. Geological Survey. 1906–08, Transitman and Asst. Res. Engr., R. R. location and const., Cananea Rio Yaqui and P. R. R. Co. 1908–11, Real estate business, general engrg. work. 1911–16, Field Asst., West Va. Geological Survey.
Present position—1916 to date: Engr. and Asst. to W. L. Cumings, Geol., Bethlehem Steel Co.

Lee Stone Twomey, Cleveland, Ohio.
Proposed by Zay Jeffries, Theron D. Stay, R. H. Allport.
Born 1886, Jeffersonville, Ind. Electrical Engrg., Purdue Univ., B. S. 1909–19, General engrg. experience with National Lamp Works, General Electric Co. 1914–19, In charge of designing, construction and operation of apparatus for production of tungsten and molybdenum and mfg. of products.
Present position: Engr., Cleveland Wire Div., National Lamp Works, General Electric Co.

Francis M. Van Tuyl, Golden, Colo.
Proposed by J. C. Roberts, Victor Ziegler, V. C. Alderson.
Born 1887, Denmark, Iowa. 1915, Univ. of Iowa, B. A. M. S. Columbia Univ., Ph. D. 1911–12, Asst., geol. and mineralogy, Univ. of Iowa. 1912–13, Fellow in geol., Columbia Univ. 1912, summer, Geol., Iowa Geol. Survey. 1913–14, Asst. in geol., Columbia Univ. 1914–15, Research in Univ. of Chicago for State Geol. Survey of Iowa, Ill., and Mo. 1915–17, Instructor in geol. and mineralogy, Univ. of Ill. 1916, summer, Geol., Univ. of Ill. Hudson Bay Exploring Expedition. 1918, summer, Geol. for Metropolitan Exploration Co. in oil fields of Kansas and Okla.
Present position—1917 to date: Assoc. Prof., Colorado School of Mines.

John Calvin Williams, Ridgway, Pa.
Proposed by E. W. Hess, H. M. Kanarr, G. F. Dunkle.
Born 1852, Richardsville, Pa. 1870, Common School. 1898–1907 Geol. for N. T. Arnold. 1907–10, Geol. for Samuel Murphy, Okla. 1910–12, Clansan Silver Min. Co., Elk Lake, Canada. 1913–14, Geol. on coal for R. W. Beadle. 1914, Coal oil and gas fields, Pennsylvania and West Va. 1915–16, Geol., Whitman Steele Co. and Hanley Bird Oil Co.
Present position—1917 to date: Cons. Geol., The Elk Fire Brick Co., St. Marys, Pa.

Henry Ellsworth Wood, Denver, Colo.
Proposed by J. V. N. Dorr, W. R. Ingalls, John C. Montgomery.
Born 1855, Joliet, Ill. 1873, Sheffield Scientific School of Yale College, Ph. B. 1876–1919, In Colo. conducting a general assaying and chemical laboratory. 1876–78, Boulder, Colo. 1878–87, Leadville, Colo. 1887–1919, Denver, Colo. 1898, Started the Henry E. Wood Ore Testing Co. Erected and operated various mills in Colo., Cal., Oregon, Canada, etc.
Present position: Pres., Henry E. Wood Ore Testing Co.

Joseph Hyman Woolf, Jr., Chosen, Korea.
Proposed by A. R. Weigall, J. Mitchell Roberts, D. W. Leeke.
Born 1890, Greeley, Colo. 1896–1908, Greeley Public School. 1908–14, Colorado School of Mines, E. M. 1911–12, Waste Gang, Homestake Min. Co., Lead, S. Dak. 1914–16, Testing Engr. and charge of Cottrell Test Plant, International Smelt. Co., Tooele, Utah. 1916, Leasing, Boulder County. In charge tungsten property, Colorado. 1916–17, Mill Statistician.
Present position—1917 to date: Prospecting and Development, Seoul Min. Co.

Associates

Edmund Guilford Brown, Rancagua, Chile.
Proposed by L. T. Higgins, J. H. Lewis, Ross E. Douglas.
Born 1890, Medford, Mass. 1904–08, Medford High School. 1908–15, Mass. Inst. of Tech. 1909, summer, Mucker, Bunker Hill & Sullivan Min. & Concentrating Co. 1911, summer, Timberman's Helper, Utah Apex Min. Co. 1912 summer, Millman Utah Apex Min. Co. 1915 to date, Asst. Shift Foreman, Experimental, Acting Mill Met., Foreman Retreatment Plant, and Mill Met., Braden Copper Co., Rancagua, Chile, S. A.
Present position: Mill Met., Braden Copper Co.

Earl Adam Trager, Bartlesville, Okla.
Proposed by Everett Carpenter, L. C. Snider, Alex. W. McCoy.
Born 1893, South Bend, Ind. 1913–14, Michigan Agri. College. 1914–15, Univ. of Nebraska. 1915–17, Univ. of Chicago, S. B. 1917, Field surveying, Wyoming, Empire Gas & Fuel Co. 1917 to date, in charge of geol, research laboratory, Empire Gas & Fuel Co.
Present position: Asst. Research Geol., Empire Gas & Fuel Co.

William Paul Zabel, East Cleveland, Ohio.
Proposed by Theron D. Stay, Zay Jeffries, R. H. Allport.
Born 1886, Sharon, Wis. 1904, Sharon Public School. 1905, Univ. of Wis., B. S. 1909, Apprentice Course, Bullock Works, Allis Chalmers Co., Cincinnati, Ohio. 1909–11, Engrg. Dept., National Lamp Works of General Electric Co., Nela Park, East Cleveland, Ohio. 1911–15, Foreman, Cleveland Wire Division, General Electric Co., Cleveland, O.
Present position—1915 to date: Engr. in charge of Wire Laboratory, Lamp Development Laboratory, National Lamp Works, General Electric Co.

Junior Associates

James Yuen Chan, Columbus, Ohio.
Proposed by H. E. Nold, Wm. J. McCaughey, Frank A. Ray.
Born 1897, Canton, China. 1914–17, Franklin High School. 1917–18, Case School of Applied Science.
Present position: Student, Ohio State University.

Ching-Lien Chang, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1895, Nanyang, Honan, China. 1908–13, Secondary School of Honan Normal College. 1913–18 Government University of Peking.
Present position: Student, Colorado School of Mines.

Chen-Te Chiang, Columbus, Ohio.
Proposed by H. E. Nold, Wm. J. McCaughey, Frank A. Ray.
Born 1896, Shanghai, China. 1912–16, Fuh-Tan College, 1916–18, University of Wisconsin.
Present position: Student, Ohio University.

Tse Yue Chow, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1895, Yeyang, Hunan, China. 1905–09, First Grammar School of Yeyang. 1909–13, Changsha Union Middle School, Hunan. 1913–16, School of Mines, Hunan Polytechnical Institute. 1916–17, University of California. 1914, summer, Asst. Surveyor and Chem., Ping-hiang coal mine, China. 1915, summer, Shua-kow-Shang lead and zinc mine. 1916, Asst. Mine Inspector, Hunan Min. Board.
Present position: Student, Colorado School of Mines.

Oscar B. Feldser, State College, Pa.
Proposed by Wm. R. Chedsey, E. S. Moore, C. P. Turner.
Born 1897, Harrisburg, Pa. 1917, summer, Helper, Bethlehem Steel Co., Steelton, Pa., 1918, summer, Asst. Met., American Steel & Wire Co., Worcester, Mass.
Present position: Student, Pennsylvania State College.

Chee Kin Ho, Columbus, Ohio.
Proposed by H. E. Nold, W. J. McCaughey, Frank A. Ray.
Born 1897, Hong Kong, China. 1909–16, Diocesan School. 1916–18, Univ. of Illinois. 1917, summer, foundry work, Gisholt Machine Co., Madison, Wis.
Present position: Student, Ohio State Univ.

Napoleon Bonaparte Larsh, Rolla, Mo.,
Proposed by Horace T. Mann, C. R. Forbes, G. H. Cox.
Born 1897, Nebraska City, Neb. 1911–15, Nebraska City High School.
Present position: Student, Missouri School of Mines and Met.

Marcial E. Martinez, Cambridge, Mass.
Proposed by H. O. Hofman, Edward E. Bugbee, Charles E. Locke.
Born 1896, Antofagasta, Chile. 1915, Grad, Escuela de Ingenieros de la Armada le Chile.
Present position: Student, Mass. Institute of Technology.

James Walter Scott, Rolla, Mo.
Proposed by Horace T. Mann, G. H. Cox, C. R. Forbes.
Born 1899, Rolla, Mo. 1905–12, Rolla Public School. 1912–15, Rolla High School.
Present position: Student, Missouri School of Mines.

Walter R. Wolley, So. Bethlehem, Pa.
Proposed by Jos. W. Richards, Howard Eckfeldt, Henry S. Drinker.
Born 1896, Ocean Grove, N. J. 1911–15, Asbury Park High School.
Present position: Student, Lehigh University.

Change of Status—Junior to Member

Agustin S. Horcasitas, Ecuador, S. A.
Proposed by Henry S. Drinker, Howard Eckfeldt, Benjamin L. Miller.
Born 1890, Chihuahua, Mexico. 1905, Private tutor. 1905–06, Fordham Prep hool, New York, N. Y. 1906–09, New York Military Academy. 1909–13, Lehigh iv., M. E. 1913, Asst. Engr., J. R. Countryman, Cripple Creek, Colo. 1913–14, sayer and Sampler, Maxwell Land Grant Co., Baldy, New Mexico. 1914, Mill reman, Assayer, Tonopah Gold Min. Co., Sweetwater, Nev. 1914–16, In siness in Mexico. 1916–17, Stope Engr., Cananea Cons. Copper Co., Cananea, nora, Mexico. 1917, Engrg. Dept., Ray Cons. Copper Co., Ray, Ariz. 1918, sayer, New Jersey Zinc Co. Palmerton, Pa.
Present position—1918 to date: Engr., South American Dev. Co.

Clark Bailey Carpenter, Girard, Kans.
Proposed by C. M. Young, Alfred L. O'Brien, C. D. Demond, E. A. Barnard.
Born 1888, Girard, Kans. 1904–08, Girard High School. 1908–10, 1913–15, grg. School, Univ. of Kansas. 1910–11, Colorado Fuel & Iron Co. 1915, Ray ns. Copper Co., Ray, Ariz. 1915–16, In charge chem. and met., Kansas State ool of Mines and Met. 1916–17, Testing dept., Anaconda. Copper Min. Co., aconda, Mont.
Present position—1917 to date: 1st Lieut., Co. B, 23rd Engrs., U. S. A.

SUMMARY OF THE TIN SITUATION*

The tin situation in this country continues inactive and unsettled, caused mainly by the large stocks in the hands of the Government and of large consumers, and the restrictions on imports, except ore purchases by domestic smelters. In order to stabilize the erratic market which was so prevalent during the first half of 1918, announcement was made in September of the inter-allied control. By this arrangement, buying in the primary markets was done by Government agencies, and no tin could be imported into the country except through the United States Steel Products Co. From the inter-allied purchases, there was allocated to the United States about 10,000 tons, at a price approximately 72½ c. per lb., f. o. b. Eastern points.

It is estimated that the consumption of tin will be largely curtailed during 1919, and probably will not exceed 3,500 tons per month. It is thought the requirements can be easily supplied by domestic smelters using foreign ores, supplemented by the stocks now on hand.

In this country there are at present two companies prospecting tin deposits—one in Rockbridge Co., Va., and the other in the Black Hills, S. Dak. The Virginia deposit, which was tied up in a legal tangle, was commandeered by the War Department, and later turned over to a Boston company to develop. Work was started about the first of October, 1918, to clean out some of the old workings, and was still under way at last report. Near Hill City, S. Dak., the Cowboy mine, formerly owned by the Harney Park Company, was acquired by a St. Louis company about two years ago, and the work of unwatering the old shaft was begun. Financial difficulties caused the work to be suspended for a time, but it was recently reported again under way.

A soft blue-white diamond weighing 388¼ carats, was recently found at the Jaegersfontein mine, Orange River Colony.

The Ambrine treatment for burns and wounds heals without scars, contractures, or functional disability, and lessens the period of convalescence. It is used as a standard treatment by the Allied and American armies.

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* Report of Bureau of Mines.

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Meets first Monday of each winter month.

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Holds four sessions during year. Annual meeting in September or October.

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Meets second Saturday of each month.

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Meets second Tuesday of each month.

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Tulsa—ALF. G. HEGGEM, chairman; JAMES H. GARDNER, secretary-treasurer, Tulsa, Okla.

Washington, D. C.—HERBERT C. HOOVER, chairman; A. G. WHITE, secretary-treasurer, U. S. Bureau of Mines, Dept. of Interior Bldg.

Mexico (Instituto Mexicano de Minas y Metalurgia.)—VICTOR M. BRASCHI, chairman, Committee on Organization.

OFFICERS AND DIRECTORS

For the year ending February, 1920

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BRADLEY STOUGHTON, ... NEW YORK, N. Y.

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CHARLES F. RAND,[3]	District 0	NEW YORK, N. Y.
LOUIS S. CATES,[3]	District 7	RAY, ARIZ.
STANLY A. EASTON,[3]	District 5	KELLOGG, IDA.

[1] Until Feb., 1920. [2] Until Feb., 1921. [3] Until Feb., 1922.

DATE		TITLE OF POSITION AND CHARACTER OF EACH ENGAGEMENT (Make statement brief and concise: any necessary amplification may be made by letter.) Failure to give complete information will cause delay. Give dates chronologically with every engagement, including consulting work of at least six months' duration. It is also desirable to make mention of important publications and original researches or investigations in laboratory or field work: also inventions and any honorary degrees or other distinctions received. Proper names, names of companies, etc., should be written without abbreviation.	TIME.		NAME AND ADDRESS of some one familiar with each engagement, preferably the person to whom applicant reported
From	To		Total Time	In Responsible Charge	

Grade	General Requirement	Age (Minimum)	Length of Active Practice	Responsible Charge of Work
Member....	Professional Mining Engineer, Geologist, Metallurgist or Chemist.	27 years	6 years*	3 years
Associate...	Any one interested in mining, geology, metallurgy, or chemistry.			
Junior Associate..	Engineering student who has not received technical degree.			

FOR ADMISSION / TRANSFER OF

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Received______________________

Bulletin______________________

Elected______________________

Second Notice______________________

Third Notice______________________

Final Notice______________________

REQUIREMENTS FOR MEMBERSHIP

Extract From Constitution

ARTICLE II

Members

Sec. 1. The membership of the Institute shall comprise four classes, namely: Members; 2. Honorary Members; 3. Associates; 4. Junior Associates.

All members shall be equally entitled to the privileges of membership, excepting at Honorary Members, Junior Associates, and Members and Associates whose sidences shall be outside of the United States, Mexico, and Canada, shall not be .titled to vote. Members and Associates residing within the United States of merica, Mexico, and Canada, and not in arrears for dues, shall be entitled to vote in rson at the meetings of the Institute, or, as hereinafter provided for, by letter llot.

Sec. 2. MEMBERS shall comprise all those persons who on the third Monday February, 1918, were members of the Institute, and in addition thereto, all those ereafter elected or transferred into the class of Members.

MEMBERS must be at least 27 years of age and must have had at least six years' nployment in the practice of engineering, mining, geology, metallurgy or chemistry, ring at least three years of which they must have held positions of responsibility in e or more of these fields.

Graduation from the scientific course of a college, approved by the Committee on embership, shall be considered equivalent to two years' employment, as required the previous sentence.

Employment as a teacher of engineering, mining, geology, metallurgy or chemistry, in direct charge, may be considered a position of responsibility as specified in the cond preceding paragraph.

Persons employed in research or any scientific literary work or in teaching in the ientific departments of colleges, approved by the Committee on Membership, who the same time are engaged in consulting or in the active practice of mining, geology, metallurgy, shall be entitled to consider the time so spent in active practice as uivalent to an equal length of time of employment in positions of responsibility, ovided the work done or the positions held seem to the Committee on Membership warrant the equivalency.

The requirement of three years' employment in positions of responsibility may be aived by the Committee on Membership in the case of persons who have done notable iginal work in mining, geology, or metallurgy, or have won distinction by research or vestigations in one or more of these subjects. By investigation or research is derstood laboratory experimentation as distinct from investigations in literature compilations of the work of others.

ASSOCIATES shall be those who, in the opinion of the Committee on Membership d the Board of Directors, are suitable for such election or transfer by reason of their terest in or connection with mining, geology, metallurgy, or chemistry.

JUNIOR ASSOCIATES shall comprise all students in good standing in engineer-g schools, who have not taken their degrees and are nominated by at least three embers, two of whom must be their instructors. A Junior Associate may remain ch not longer than five years after leaving the engineering school, at the end of hich period his qualifications to become a Member or Associate must be passed on by the Committee on Membership. If elected he shall pay at that time the trance fee and dues of a Member or Associate.

In case there is any question as to the classification of a candidate the Committee Membership may require from him any evidence he desires to present and the cision of the Committee as to the proper status shall be final.

Every candidate for election as a Member, Associate, or Junior Associate must be oposed for election by at least three Members or Associates, must be approved by e Committee on Membership, as prescribed in the By-Laws, and must be elected the Board of Directors

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Tunnel Driving at Copper Mountain, B. C.

BY OSCAR LACHMUND, E. M., SPOKANE, WASH.

(Chicago Meeting, September, 1919)

DURING the driving of the main haulage level at the Copper Mountain mines of the Canada Copper Corpn., Ltd., near Princeton, B. C., some very rapid driving was done, though no claim for a world's record is made. Conditions, however, were unfavorable for economical operations. The cost of power was high, for the fuel was of poor grade; besides, during the time the work was in progress, very little other power was needed so that most of the power cost was charged against the footage. The

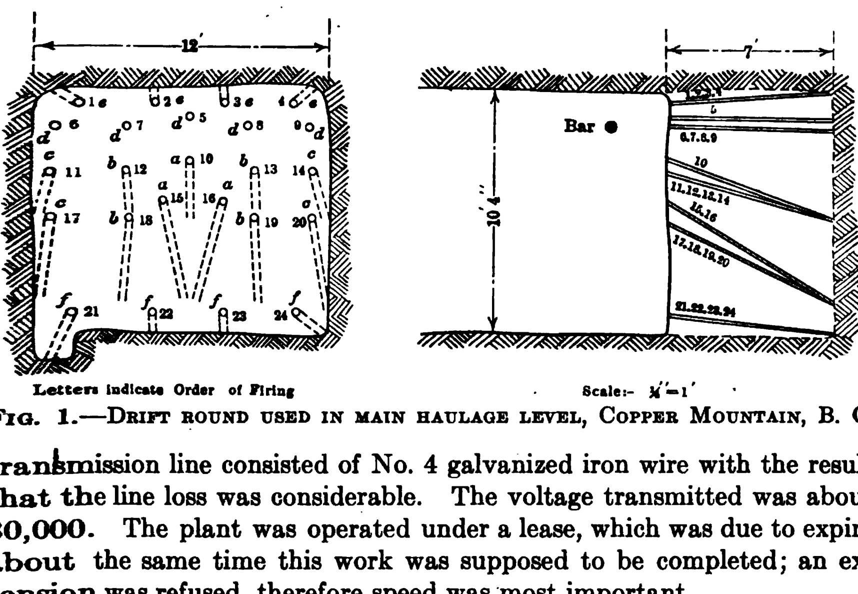

FIG. 1.—DRIFT ROUND USED IN MAIN HAULAGE LEVEL, COPPER MOUNTAIN, B. C.

transmission line consisted of No. 4 galvanized iron wire with the result that the line loss was considerable. The voltage transmitted was about 30,000. The plant was operated under a lease, which was due to expire about the same time this work was supposed to be completed; an extension was refused, therefore speed was most important.

The plans called for a straight adit 2900 ft. (884 m.) in length. At a point 2800 ft. (853 m.) from the portal, two raises were to be put up to the next nearest workings, a difference in elevation of about 800 ft. (243 m.). One of these was to be a two-compartment hoistway and the other a zigzag ore pass, or muck run. A location for these raises had been determined by a number of diamond-drill holes, but the material to be penetrated by the adit was not known. It seemed imperative to get the tunnel work completed as rapidly as possible, in

order to allow for delays in the raising program, which were certain to occur. To show how closely these operations were timed, it is interesting to note that the date of expiration of the power-plant lease was Sept. 1, 1918, and the last round, making the connection between the upper and lower workings, "broke through" in the night of Sept. 3, 1918.

The plans called for a tunnel 9 ft. (2.7 m.) high by 11 ft. (3.3 m.) wide; but owing to the "blocky" nature of some of the rock a considerable "over break" occurred. This enlarged the tunnel cross-section to 10.4 ft. by 12 ft. (3.2 by 3.6 m.) indicated by measurements taken at 200-ft. (60-m.) intervals after the work was finished and slowed up the work on account of the extra waste handled, besides increasing the cost per foot of driving. Several regions of geological disturbance were crossed and the heavy ground encountered called for timber supports. More than 350 ft. (106 m.) of heavy timbering was necessary at various points along the course of the tunnel; this also retarded the work to the extent of about 6 ft. (1.8 m.) per day for each set of timber placed. Once the working foree was organized and the work well under way, three shifts were put on, working 8 hr. each.

The drills used were the dreadnaught No. 60. They were mounted four on a horizontal bar, from which position all but the four bottom holes, or "lifters," were drilled, the miners working on the muck pile. Upon completion of the upper part of the round, most of the muck had been removed; that which was left was rapidly thrown back from the face, all hands helping on this work. The horizontal bar was then torn down and dropped to the lower position, from which the lifters were drilled. The change of the bar from the upper to the lower position, together with drilling the lifters, loading, and firing the entire round, was frequently made in 50 minutes.

The holes were pointed to pull a 7-ft. (2-m.) round and averaged about 9 ft. (2.7 m.) in depth. The center, or "cut holes," were fired first, after which followed the side holes, then the back holes, and finally the lifters. The drift round commonly used in this work is illustrated in Fig. 1, which also indicates the firing of the holes in groups. The blasting was done by hand, the fuses being "spit." The timing of the shots was regulated by cutting the fuse in different lengths; the shortest for the center holes, the next longest for the side holes, and so on. The lifters were loaded with extra heavy charges of powder, so as to throw the muck back from the face as much as possible. This was sometimes helped by placing charges of explosive outside and beneath the lifters; these were called muckers, and were set to go off after the rest of the round had been fired.

The powder used was a non-freezing kind, varying in strength from 40 to 60 per cent. nitroglycerin, depending on the hardness of the rock at the face.

The rock was handled in small, V-shaped, hand-dump cars of about 1000 lb. (453 kg.) capacity. Tramming was done by hand until the distance from heading to dump became too great, when horse haulage was substituted; later this was replaced by an electric installation. Steel plates were laid on the bottom for a distance of 30 to 40 ft. (9 to 12 m.) from the face, to facilitate shoveling, also to permit shunting empty cars past the loaded trains and thereby eliminating the need for double track.

The cars, being light, were easily pulled from the track and, with bodies tilted, were passed on the steel plates, alongside of the loaded cars and then pushed back on to the track at the muck pile and loaded. Temporary track was laid close up to the face before firing a round. The T-rails were laid on their side, allowing the flanges of the car wheels to run on the grooves thus formed.

The foul air and gases were removed, after each round was fired, by a Connersville rotary blower, of 10 cu. ft. (0.28 cu. m.) capacity, stationed at the portal of the tunnel. Later, a similar machine was placed about halfway in the adit and worked in tandem with it. The blowers were set to exhaust toward the surface through a 12-in. (30-cm.) wire-wound, wooden stave pipe. The men were able to return to the heading within 15 min. after firing.

The mucking crew was divided into three gangs, on each shift, averaging 11 men per shift. The work was divided so that one gang was shoveling muck, another was picking down from the muck pile, while the third was bringing up empty cars and forming them into trains after they were loaded. This latter work did not take up the entire time, so that this gang had an opportunity to rest. As soon as a train was loaded, the gangs changed jobs; that is, the pickers went at shoveling, the car handlers took the picks, and the shovelers took the easy work, and so on. Greater efficiency was maintained in this manner, as the change of work tended to rest the men and they were able to work continuously.

A bonus system was also a large factor in keeping the men up to the mark. This was based on a daily advance of 9 ft. (2.7 m.), upon which the then "going" wages were guaranteed; for all advance over 9 ft., $6 per foot was added as bonus. For each set of timber placed, an allowance of 3 ft. (0.9 m.) was made, which applied on the bonus. Current wages at the time were $4.50 for miners, $4 for helpers, and $3.50 for common labor. The bonus distribution brought these amounts up to $5.91 for miners, $5.25 for helpers, and $4.59 for muckers. The foreman and the shift bosses also shared in the bonus, the distribution being made by pro-rating the bonus in the same ratio as the amount of regular wage received by each man. Everybody seemed satisfied and no difficulties were experienced as far as the labor situation was concerned.

The work was begun on Oct. 9, 1917, and the tunnel was finished

Mar. 11, 1918, a total of 154 days. The actual working time was 150 days, four days being lost on account of a break in the power line.

The length of the adit is 2903 ft. (884.8 m.) and the daily average progress was 19.3 ft. (5.8 m.) for each working day. The greatest advance in any one month was in December, 1917, when a total of 645 ft. (196 m.) was driven. The amount of rock handled is estimated at 185 tons per day. The material penetrated was granodiorite, for the greater part of the distance. The total cost of driving the tunnel was $103,242.15, which brings the cost per foot of tunnel to $35.56. Certain equipment and supplies were charged against the work that should have been carried in a suspense account, as most of these had a certain salvage value because it was intended to use them in the future operation of the mines. For reasons already mentioned, such as expensive power, the cost given does not really represent the actual expense of driving. Had speed not been so important, no doubt the work could have been done more cheaply. A few of the cost items are as follows:

	Totals	Unit Cost
Total Driving Cost		
Labor	$25,517.81	$8.80
Explosives	16,616.75	5.72
Drills, parts and repairs	2,767.82	0.95
Steel, sharpening and replacement	3,979.78	1.37
Miscellaneous supplies	1,908.27	0.66
Power	8,410.24	2.90
	$59,200.67	$20.40
Rock Disposal		
Labor	$21,843.40	$7.52
Supplies	1,685.24	0.57
Power	558.64	0.20
	$24,087.28	$8.29
Timbering		
Labor	$1,335.52	$0.46
Timber and supplies	2,513.18	0.86
	$3,848.70	$1.32
Indirect Expense		
Air and water lines	$5,439.09	$1.88
Electric lighting	1,018.81	0.35
Ventilation	3,198.38	1.10
Dump, tracks, and trestles	503.67	0.17
Depreciation on drills	970.76	0.33
Depreciation on cars	301.82	0.11
Surface hoisting and hauling	3,464.58	1.19
Miscellaneous supplies	1,208.39	0.42
	$16,105.50	$5.55
Total cost	$103,242.15	$35.56

Timbering details	
53 sets timber installed, cost per set	\$72.62
354 ft. of tunnel timbered, cost per foot	10.83
Drilling Details	
Actual drilling hours	8022
Actual working days	149 11/12
Average drilling hours per day	53.50
Cost of upkeep per drilling hour, in cents	22.53

Before planning any of the work, the engineer in charge visited large mining properties in the West and Southwest, where all the latest methods were observed. From notes taken upon these trips, the layout for future work was developed. The method of driving the main haulage level was derived from the operation of the Pioneer Tunnel at Glacier, B. C., a few years ago, by the Canadian Pacific Railway.

The credit of working out the plans and details of this work belongs to Mr. F. S. Norcross, Jr., at that time superintendent of mines of the Canada Copper Corpn., now a captain in the 27th Regiment of Engineers, the mining regiment, at present in France. Captain Norcross was unable to complete the job, as he enlisted in December, 1917, but the work was carried out by his successor and former assistant engineer, Mr. P. E. Crane.

Distribution of Coal Under U. S. Fuel Administration

BY J. D. A. MORROW,* WASHINGTON, D. C.

(New York Meeting, February, 1919)

THIS discussion relates to the distribution of coal under the direction of the U. S. Fuel Administration beginning Apr. 1, 1918. At that time a definite method of controlling and directing distribution was put into effect. Prior thereto, although some of the machinery utilized was in operation, especially in the few weeks immediately preceding Apr. 1, distribution had not been effectively and comprehensively organized.

The writer was called to the Fuel Administration by Dr. Garfield about the first of February, 1918, to assume general direction of the distribution of coal for the Fuel Administration, to develop the general plans, and to obtain practical men to assist in this work and in carrying through the program finally devised. A study of the situation and conferences with the Fuel Administrator and leading men in the business made it plain that it would be necessary to begin at the bottom, measure the undertaking, develop plans to meet the need thus shown, and build an organization to effect the distribution required. This work had to be done under war pressure in the midst of a bad coal shortage.

The successful performance of such a task is always primarily a matter of putting competent men in the right places and giving them the power and opportunity to function properly together. In the Distribution Division of the U. S. Fuel Administration, the men who were chiefly responsible for whipping plans into practical form and then for carrying out these plans were A. W. Calloway, of Baltimore, President of the Davis Coal & Coke Co., who served as the Director of Bituminous Coal Distribution; S. Lovell Yerkes, of Birmingham, Alabama, Secretary of the Grider Coal Sales Agency, who assumed general charge of distribution while the new plans and organization were being perfected and then became the Assistant Director of Bituminous Coal Distribution; Warren S. Blauvelt, of Detroit, who was Director of Coke Distribution; A. S. Learoyd of New York, Director of Anthracite Distribution, in connection with the Anthracite Committee, consisting of Joseph

* General Director of Distribution.

P. Dickson, President of Dickson & Eddy, Chairman; S. D. Warriner, President of the Lehigh Coal & Navigation Co., and W. H Richards, President of the Philadelphia & Reading Coal & Iron Co.; A. M. Ogle, of Terre Haute, President of the Vandalia Coal Co., Director of State Distribution; and C. E. Lesher, Coal Statistician of the U. S. Geological Survey, who was kindly loaned by Director Smith to become Director of Statistics for our Distribution Division.

One of the first requisites in obtaining tangible results was to know how much coal would be required during the year, where it would be needed, and for what purposes. Without this information, it was impossible to make any definite plans for supplying the war needs of the nation. The first estimates of the Bureau of Statistics called for 736,000,000 short tons of coal. Subsequently, through known conservation of coal and through effective control of distribution, which made it possible to lower some estimates of necessary winter reserves, the figure was reduced to 723,400,000 tons. Of this amount 100,000,000 short tons was the estimated maximum possible output of anthracite, and the balance was the tonnage of bituminous coal required to fill all remaining coal needs.

The bituminous tonnage was classified to show the requirements for railroads, exports, ship bunkers, domestic consumers, public utilities, and industrial concerns. These latter were still further subdivided to give the requirements of particular industries, such as byproduct coke plants, iron and steel plants, etc. The tonnage needed for domestic consumers, public utilities, and industrial concerns was estimated by states, but that for railroads, exports, and bunkers was not so divided because in the distribution of coal for these purposes state lines were ignored. Distribution for the other consumers was placed on a state basis to insure equality of treatment among consumers in different parts of the country.

Anthracite requirements for domestic use were estimated with even greater care. The Anthracite Committee ascertained the shipments of domestic anthracite, in 1916, into some 22,000 communities. On the basis of these shipments, estimates of the needs of these communities for 1918 were prepared by the State Fuel Administrators and the Anthracite Committee and definite allotments of anthracite were made by states and communities. In order to supply the estimated needs of the northern and eastern states in which war activities had led to increases of population in many localities, it was necessary to withdraw anthracite from the western and southern states entirely and to decrease the shipments into various middle western states and parts of Canada.

Comparison of Schedules and Shipments

With the requirements thus known, schedules were set up covering the movement of coal from the mines to the various consuming areas

week by week throughout the year, allowing for differences in transportation conditions in summer and winter and making provision for sufficient winter reserves in the more remote consuming districts. These schedules were worked out in coöperation with the U. S. Railroad Administration and the shipments of coal were constantly checked against them. The more important movements, such as shipments of Navy and transport bunker coal were under daily check.

To show how these schedules were observed and how the movement approached and eventually surpassed the figures scheduled as production increased and as war activity stopped with the signing of the armistice, let me say that on July 6, for example, the rail movement of bituminous coal to New England totaled 3,058,000 tons since Apr. 1, against a schedule calling for 3,150,000 to this date, or 98 per cent. performance. On Sept. 28, rail shipments totaled 6,164,000 tons against a schedule of 5,849,000, or 105.4 per cent. performance. On Dec. 21, rail shipments totaled 7,763,000 tons against a scheduled total of 7,459-000, or 104.1 per cent. performance. On July 1, scheduled shipments to tidewater at ports from Hampton Roads north were 11,916,000 tons; actual shipments were 11,557,000, or 97 per cent. of the schedule. On Sept. 1, we had scheduled for those ports 19,860,000 tons and actual shipments totaled 20,013,000 tons, or 100.8 per cent. performance. On Oct. 21, the figures were 23,963,000 tons scheduled and 23,843,000 shipped. On Dec. 21, thanks to the armistice, the shipments had run 2,688,000 tons, or 9 per cent., ahead of the schedule. A total of 28,000,000 tons was scheduled to go up the Great Lakes for the northwestern states and Canada; we sent 28,153,000 tons. With similar precision and certainty, munition factories, arsenals, powder works, byproduct plants, etc., were kept running while stocks were accumulated insuring uninterrupted operation throughout the winter. In the same manner, retail dealers were given supplies for their domestic trade. Such results were only possible because of the complete control of shipments and the full information on which to proceed.

Supervision of Distribution

The bituminous producing fields were divided into 28 districts, with a District Representative in charge of the operators in each of these fields. These men were under the direct supervision of Messrs. Calloway and Yerkes. They had full information of the production, the obligations and shipments of producers in their respective territories, and executed the orders from Washington for the movement of coal from the mines to carry out the plans for the distribution of bituminous coal. A similar arrangement prevailed for coke. Each of these District Representatives obtained daily reports of the shipments from every mine under his jurisdiction. Each was a man in whom the producers had confidence,

and they enjoyed the fullest and most loyal help and coöperation of the producers. Thus the coal operators themselves were organized into a part of the distribution machinery of the Fuel Administration.

Distribution among consumers in each state was supervised by a State Fuel Administrator, who had no interest in the coal business but whose duty it was to see that all consumers were treated impartially, and to call upon the District Representatives to assist any who might be in special need of coal. The distribution work of these state administrators was supervised, so far as was necessary, in Washington, by Mr. Ogle, the Director of State Distribution. He was constantly in close touch with the heads of the bituminous, anthracite and coke distribution bureaus.

Reports and Priorities

To control and direct the movement of 2,000,000 tons of coal daily to 100,000,000 consumers, it was necessary to have not only current reports from the shippers at the 6000 mines to the District Representatives, but also weekly reports from some 90,000 industrial consumers and retail dealers. Duplicate reports went to each State Administrator. The Bureau of Statistics daily, under Mr. Lesher, checked, tabulated, and summarized reports from approximately 15,000 consumers and the information thus assembled went to the various executives who were supervising shipments.

To insure a distribution of coal that would contribute most directly to the nation's war program, particularly of the special grades of coal, it was necessary to have some degree of preference established among the various classes of consumers. That order of preference was fixed by Bernard M. Baruch, Chairman of the War Industries Board, working through the Priorities Board, of which Judge E. B. Parker was chairman. The entire distribution program of the Fuel Administration accorded with the preference as laid down by the War Industries Board. Consumers in Classes 1 and 2 were supplied first and were given ample stocks of coal before consumers in the lower classes were allowed to accumulate reserves.

Coöperation with Railroad Administration

As a part of the effort to coöperate with the United States Railroad Administration most effectively, and as a practical means of insuring the movement of coal with a definite saving in transportation, a zone system of distribution from the mines to the consumers was applied in the central and southern part of the United States between the Rocky Mountains and the general line of Erie, Pittsburgh, and Baltimore. Such a system was under consideration by the Railroad Administration and the Fuel Administration prior to my connection with the latter. The plans

for this system were pushed to completion and it was put into effect on Apr. 1. The northeastern part of the country was not zoned because of the complexity of supplying that section; on the other hand, the western part of the country was not zoned because it divides itself geographically and so zones itself. The zone system was not administered rigidly, but was modified as fluctuations in production required and as was necessary to permit the requisite movement of coals for special industrial uses, such as gas, byproducts, metallurgical, railroad fuel, etc. The system saved 160,000,000 car miles in hauling coal from April to December and obtained a quicker return of empty cars to the mines. It also helped to equalize the demand in different sections of the country, which, in turn, permitted the mines in all fields to run more nearly to capacity than ever before.

This excellent paper, which contains 21 illustrations and three tables, has been printed in full for distribution at the meeting. Copies of it will be sent, free of charge, to all persons who are interested.

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Manganese Ore Deposits in Cuba*

BY ERNEST F. BURCHARD,† M. S., WASHINGTON, D. C.

(Chicago Meeting, September, 1919)

ABSTRACT

A RECONNAISSANCE of the manganese- and chrome-ore deposits of Cuba was made by the writer, as a representative of the U. S. Geological Survey, in company with Mr. Albert Burch of the Bureau of Mines under instructions of the Secretary of the Interior, in the Spring of 1918. The object of the study was to obtain authentic information for the use of the United States Government as to the location, character, quantity, and availability of the manganese- and chrome-ore deposits in Cuba. Accordingly, the work comprised the examination of such deposits as seemed to be of promise, without regard to stage of development, with a view to determination of the quantity and quality of ore likely to become available for shipment during 1918 and 1919, and of the tonnage of ore in reserve. While it was possible to visit most of the deposits that seemed to be of promise, there was not sufficient time to visit all that were brought to our attention, some of which may have merit.

Manganese ore is found in Cuba in Oriente, Santa Clara, and Pinar del Rio Provinces, but in Oriente Province only does it occur in large commercial quantities. There, the deposits are in three areas: one north of Santiago de Cuba, one south of Bayamo and Baire, and one on the Caribbean coast between Torquino Peak and Portillo. In Santa Clara Province, a little ore has been found near the Caribbean coast west of Trinidad; and in Pinar del Rio Province, manganiferous material occurs north of the city of Pinar del Rio and farther west near Mendoza.

The manganese ores of Cuba occur, principally, in sedimentary rocks, such as limestone, sandstone, and shale, that are in places metamorphosed, and in beds that originally may have been water-laid tuff

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† Geologist, U. S. Geol. Survey.

but are now partly replaced by manganese oxide, zeolites, calcite, and other minerals. In the most heavily mineralized localities, the deposits are in and about masses of siliceous rock, locally termed "jasper" and "byate" that are associated with the country rock. At one locality south of Bayamo, the manganese and its siliceous associates are in igneous rocks, such as latite-porphyry and latite. The sedimentary rocks with which the manganese deposits are associated are, in some places, nearly horizontal but generally show dips ranging from a few degrees to 45° or more.

The area north of Santiago is, broadly speaking, in the synclinal basin between the Sierra Maestra on the south and the Sierras de Nipe and del Cristal on the north, the greater part of which is drained westward by Rio Cauto and its tributaries, and small parts of it by Rio San Juan and Rio Guantanamo to the south and east. The deposits of manganese ore are found on both sides of the basin. The deposits in the area south of Bayamo are in the northern foothills of the Sierra Maestra drained by Buey, Bayamo, Yao, and Cautillo rivers.

The deposits in the two areas north of the Sierra Maestra show an interesting concordance in altitude. They are from 500 to 1200 ft. (152 to 364 m.) above sea level, and most of them are at altitudes near 600 to 700 ft., suggesting a relation between the deposition of the manganese and a certain stage in the physiographic development of the region. Most of the manganese ore deposits are above drainage level on the slopes of hills of moderate height, the maximum relief in the immediate vicinity of the deposits seldom exceeding 500 ft. Some of the manganese ore deposits have been observed to lie on the crest and slopes of anticlinal hills, but these anticlines are but local puckerings of the strata forming the broad synclinal basin just mentioned. The foraminiferal limestones and greensand marls associated with the manganese ores in the Santiago district, and also probably along the northern foot of the Sierra Maestra south of Baire, are regarded as of upper Eocene age.

The deposits of manganese ore examined in Cuba exhibit wide variations, but they may be groupd into three general physical types: deposits in beds; deposits in irregular masses associated with siliceous rock, such as jasper or byate; and deposits in residual clay or rock debris. The term jasper is more commonly used in the Santiago district, byate in the Bayamo district.

The deposits in beds comprise several varieties, one of the most common consisting of poorly consolidated beds of sandy, tuffaceous material mixed with manganese oxides, granules of pink clay, and zeolite minerals. Such beds fill depressions in the surface and crevices and cavities within hard rocks. Other bedded deposits occur as tabular masses interbedded with limestone strata, and others are replacements of limestone, sandstone, and conglomerate beds. Pyrolusite, psilomelane, manganite, and wad, or mixtures of some or all of these minerals, are

found in the ore deposits but no manganese carbonate or silicate minerals were recognized in any of the deposits except in the metamorphosed limestone and calcareous schist near Trinidad, where ankerite and rhodonite occur in small quantities. The richness of the deposits varies considerably. Most of the richest masses are associated with the jasper, but masses that have replaced limestone thoroughly are also rich. The ore known as milling, or wash ore, is generally of the sandy, tuffaceous type, in which it is necessary to separate considerable granular gangue material from the manganese oxide.

The deposits of manganese oxide associated with masses of jasper, or byate, appear to have been one of the earliest, if not the first, of the several types of ore to be formed. The association of the jasper with adjacent rocks suggest that it has been deposited by hot spring waters, and the association of the manganese minerals with the jasper suggest that the manganese and silica have been deposited very nearly contemporaneously. If not contemporaneously, the manganese probably came in with a secondary silicification.

The production of manganese ore about the middle of March, 1918, in the Santiago district, was between 280 and 300 tons a day. The output was curtailed in the rainy season, which begins about the first of June, especially that from the smaller mines, which are dependent on ox-cart haulage, but the curtailment was more than offset by the increase in shipments after the railroad from Cristo to the Ysabelita mine was opened.

The approximate average composition of a large proportion of the ore recently shipped for metallurgical use is as follows: Manganese, 38.885 per cent.; silica, 12.135 per cent.; phosphorus, 0.084 per cent.; moisture, 11.201 per cent.

The production of manganese ore from the district south of Bayamo has amounted to a very few thousand tons altogether, the mining operations being on a small scale. In the spring of 1918, only 50 to 60 tons a day were being produced from all the mines, but much of this was high-grade ore for chemical purposes. The development of the deposits is handicapped by their remoteness from the railroad and by the lack of good wagon roads.

Conditions Affecting Manganese Industry in Cuba.—Although the owners and operators of manganese properties in Cuba desired to speed up production during the period of the war while the need for the ore was was great and the prices were good, there were certain hindrances, aside from climatic conditions, that tended to retard their output. These hindrances will, for the most part, continue to affect the manganese industry in Cuba, and unless many of them are removed and others remedied it will probably be difficult to maintain the industry in the face of reduced prices for ore. It was difficult during the war period to obtain

and hold a sufficient number of miners at certain mines, because an adequate supply of staple foodstuffs could not be furnished them. Mining was also handicapped by shortage of explosives.

There seems but little chance for improvement in the transportation of ore from mines to railroads without assistance from the Cuban Government in building and improving cart roads. Haulage by caterpillar tractors may eventually supplant some of the haulage by animals. The high cost of animal haulage prevents the production of ore from many deposits at a great distance from railroads. The limitation of this traffic to five or six months of the year also handicaps production, for though mining might be carried on during practically the whole year, ore would have to be stacked up for many months awaiting the drying of the roads, which storage would lock up considerable capital, and this few of the smaller operators can afford.

Shortage of railroad cars and the inability of the Cuba Railroad to handle adequately all the manganese ore during the dry season, when traffic is heaviest because this is also the cane grinding season, is also a serious handicap to the output of ore. During 1918, a shortage of ships permitted ore to accumulate at the docks in Santiago faster than it could be removed, but post-war conditions should be better in this respect.

The marketing of ore by small producers is attended by more or less friction between buyers and sellers over sampling and analyses. If the Cuban Government could detail two men, one a chemist and the other a man experienced in sampling ore, to act as umpires at Santiago in the sampling and analysis of manganese ore, small producers would be encouraged; this service might be made self-supporting by charging the cost to the interested parties.

The production of manganese ore seems to have been handicapped by the attitude of some owners of lands and leaseholds, who have raised the price of royalties so high as to discourage operations. In the course of its trip, the Government party heard complaints of many forms of sharp practice, which are not conducive to a hearty coöperation between property owners, miners, and buyers of manganese ore.

Despite the handicaps outlined there was strong interest taken everywhere, in Cuba, in developing manganese prospects and the operators of manganese mines made every effort to increase their output. Large investments were made at the larger properties in mine equipment, railroad spurs, and general developments so that these mines were placed in a position to produce a large output of ore.

The industrial situation at the close of 1918 is so uncertain, however, and consumers in the United States appear to have such a large stock of ore on hand that it is very doubtful whether there will be an important production of manganese ore from Cuba in 1919.

Total Production and Reserves of Manganese Ore.—Available figures on exports of manganese ore from Cuba and imports from Cuba into the United States, supplemented by estimates, indicate a total production during the period 1888 to 1918 of about 430,500 long tons of ore, valued at about $6,438,500, an average value of $14.95 a ton. The imports of Cuban ore into the United States in 1918 amounted to 82,974 tons, valued at $2,751,193, or about $33.16 a ton. The shipments of ore to the United States fell short of the possible maximum, as they suffered a curtailment through withdrawal of vessel tonnage during the summer, and, in November, the armistice halting the war in Europe further retarded production.

When each deposit of manganese ore was examined, estimates were made of its probable reserve tonnage, and of its probable production of ore, by grades, in 1918 and 1919, provided the war-time demand for ore should continue and the unusual handicaps to production and transportation of ore could be overcome. With the estimates of probable production there is now no concern, but it should be stated that events have proved that the manganese ore producers of Cuba were prepared to fulfill even more than was expected of them. With regard to the reserve ore tonnage there is a certain interest, in connection with the question of world distribution of this important steel-alloy metal, although until commercial conditions readjust themselves there may be little demand for manganese ore from Cuba. The results of the investigation indicate a total tonnage of between 700,000 and 800,000 long tons of manganese ore, containing more than 36 per cent. of manganese, in reserve in Cuba, 600,000 to 700,000 tons of which are credited to the Santiago district, 50,000 to 75,000 tons to the Bayamo-Baire district, and the remainder to all other districts, including Los Negros, Camaroncito, Trinidad, and Mendoza.

A Metallographic Investigation of Transverse-fissure Rails with Special Reference to High-phosphorus Streaks

Discussion of the paper by G. F. COMSTOCK, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 143, November, 1918, p. 1699.

JAMES E. HOWARD,* Washington, D. C. (written discussion†).—Mr. Comstock, in his classification of the possible causes of transverse fissures, has not quite caught the point of view of the writer. It appears, following the trend of thought in Mr. Comstock's paper, that three groups instead of two might be enumerated, namely: Fatigue of the steel, quality or, preferably, grade of steel, and mill practice.

All steels are liable to failure by fatigue. Stresses that are capable of causing fatigue fractures are modified in their magnitude by the grade of steel acted upon. Mill practice is a term having a very wide meaning and in its relations to the development of transverse fissures has been used with such vagueness as to include many known factors and some that are unknown in the arts. According to the grade of steel employed, fatigue fractures may be accomplished by loads of greater or less magnitude, hence there is a relation between quality, or grade, of steel and the display of fatigue fractures. Mill practice of such an order as to affect the formation of transverse fissures must be shown to exert an influence on the ability of the steel to endure repeated stresses. Different grades of steel are selected for different purposes. Steel employed for fire-box purposes is of different grade from that used for cutting tools, although each grade is suitable for its purpose, and therefore of good quality.

It is conceivable that a demand might be made for steel of physical properties in excess of those of any known grade. Under such a demand, impossible of fulfillment, it would not be proper to refer to the steels as being deficient in quality; to do so would be a failure to recognize that all steels have their limitations in strength. Service conditions peculiar to rails admit of successive advance until the conditions can no longer be met. The failure of a large number of rails from one type of failure, when all known means of averting the failure have been employed without success, is sufficient evidence that the end is close at hand.

Iron rails, for a time, successfully met the requirements of railway service but weight of equipment, motive power, and rolling stock were increased, necessitating the use of steel. The early steel rails enjoyed the reputation of being of excellent quality, although neither chemically nor structurally would they be so regarded at the present time. They did good service in their day and under the conditions then prevailing were good rails. To meet the increased weight of rolling stock there has been

* Engineer-physicist, Interstate Commerce Commission. † Received Jan. 18, 1919.

an increase in the weight of rails, at the same time practically all grades of carbon steel have been tried, with occasional efforts to use alloy steels and heat-treated rails. No grade of steel nor weight of rail yet employed has enjoyed immunity from fracture in service.

In the first report dealing with a rail fracture to which the term transverse fissures was applied, the writer expressed the opinion that this type of fracture was "due to the use of a hard steel and subjecting it to high wheel pressures, . . . causing the development and introduction of internal strains, and those internal strains together with the wheel loads caused the development of interior fissures and their extension to a dangerous degree."

It will be noted that attention was called to the presence of internal strains as a result attending the use of rails in the track. The presence of internal strains, which at times far exceed the direct stresses, had apparently been entirely overlooked on the part of railroad engineers, an omission to this day not completely overcome. Internal strains are introduced in the upper part of the head of the rail, where a range in stress from tension to compression of 28,000 lb. per sq. in. (19.68 kg. per sq. mm.) has been reached, within a depth of metal not more than ¾ in. (19 mm.). Compressive stresses located next to the running surface of the head not infrequently exceed 20,000 lb. per sq. in. (14 kg. per sq. mm.). With the occurrence of thousands of transverse fissures in recent years—they were known only in isolated cases in earlier years—the query is forcibly presented whether service conditions have not reached that stage in which the ability of steel to endure them has nearly or quite reached its limit.

Increased weights of rails furnish greater girder strength, without material modification of the impinging pressures between the wheel and the rail. The interior origin of a transverse fissure is due to the internal strains introduced by these impinging pressures. Increased weight of rail does not remove this compressive component in the head. Transverse fissures occurring in the heavier rails after a short period of ime in the track, in rails in which the direct bending stresses are much educed, place a large share of responsibility for failure on the cold-olling action of the wheels.

Interest centers upon the condition of the steel at the nucleus of the ransverse fissure, whether the inception of the fissure was caused by any ocal abnormality or was due entirely to repetition of stresses. No tructural or chemical reason common to the display of transverse fisures has been found to which their formation might be ascribed. In iven heats, these fissures have been found in rails that were laid on divi-ions where traffic conditions were most severe. Their occurrence in ard rails is probably facilitated by reason of the heads of the rails mainaining their shape with minimum distortion. After reaching a satu-

rated state of internal strain, the maximum stresses thereafter are centered upon the same elements, a favorable condition for the development of fatigue fractures.

The nuclei of transverse fissures commonly present the silky appearance so much admired in steels fractured by tension. The surrounding parts have a bright silvery luster, until the fissure has extended and reached the periphery of the rail; then the surfaces are darkened. The silvery luster is doubtless acquired by the opposite surfaces hammering each other, when the stresses in the rail are reversed and the head is in compression. The progressive development of transverse fissures is shown by the concentric ripples on their silvery faces. The walls of an incipient fissure are separated a very minute distance, probably represented by the elastic resilience of the steel in that vicinity. The phenomenon of permanent set or permanent elongation of the steel cannot take place when an interior fissure is formed in a matrix of structurally sound metal. Seamy or spongy steel would appear to favor interior flow of limited degree without fracture.

Let us consider for a moment some features in the physics of steel that must have a bearing on the inception of a transverse fissure. To be a potent influence in starting a transverse fissure in the interior of the head, in the absence of those internal strains that we know are introduced by the wheel pressures, there must be a portion of the metal devoid of such elastic properties as will prevent its extension and compression in harmony with the surrounding metal. It is not a question of toughness or brittleness in the usual sense of those terms, but one of elasticity. We are not familiar with any alloy of iron that does not possess elastic properties; steels covering a wide range in chemical composition still retain the same, or substantially the same, modulus of elasticity. Hook's law prevails also in steels prior to the application of overstraining loads. Any minute eddy in the transmission of stresses will be a negligible factor since the effect of such an eddy will merely be a moderate increase in intensity of stress in that vicinity. A non-elastic substance of considerable volume and having sharp edges will be required to cause the incipient formation of a transverse fissure. The reduction of the metal from the ingot to the rail orients seaminess and lamination parallel to the length of the rail. Interruption of continuity normal to the principal stresses is necessary in order to influence rupture.

The strains per unit of length with which we are concerned in connection with transverse fissures are less than two thousandths. Such strains in the field of the microscope represent very minute distances—millionths of an inch. It would be difficult to recognize their presence even if their characteristics, as means of identification, were known. Recalling Tyndall's familiar illustration in molecular physics, comparing an orange with the size of the earth, it seems doubtful whether the micro-

scope brings us relatively much nearer a real conception of the phenomenon of fatigue in metals than the unaided eye.

Physical properties that are obviously correlated with stresses that ultimately result in fatigue fractures have been taken under consideration in the study of transverse fissures. It is well known, (1) that the moduli of elasticity of steels are lowered by overstraining loads and that a recovery takes place during a period of rest; (2) that overstraining loads disturb the equality of elastic limits in hot-worked steel, overstraining in one direction and impairing the elastic limit in the opposite direction; (3) that internal strains are acquired by steels when cold worked and also during periods of cooling; (4) that hot-forged steel shows a difference in behavior, when annealed, in respect to the direction the metal was worked and at right angles thereto. It is also known that, with changes in carbon content, there are changes in the coefficients of expansion and in the specific-gravity values of steels. Each of these factors may have an influence on the ability of a rail to endure stresses, either from their influence on the primitive state of the rail or by affecting its condition in the track. The relations between the properties made use of in rails in service and their microconstituents are less direct and less understood.

A slight initial advantage against the acquisition of internal strains would seem to attend segregated steel, a thought at variance with specifications in which higher carbon metal in the center of the head is a cause for rejection of the rail. The lower carbon steel has the higher coefficient of expansion, in which case a nucleus of high-carbon metal in the head should acquire a state of compression. The higher carbon steel also has a lower specific gravity, and if an equal weight of the high-carbon metal was forced into the space that the same weight of low-carbon steel would occupy there would result cubic compression of the segregated metal. What happens along these lines we do not know, whether favorable or unfavorable in resisting fatigue. So great is the influence of the rate of cooling on the initial strains that the influence of other factors is overshadowed.

Sponginess of structure is occasionally witnessed in steel in the early passes in the blooming mill, disappearing commonly before the finishing pass of the rail mill is reached. Etched specimens from rail heads have exhibited similar manifestations. The presence of such indications is of interest and raises the question whether the interior sponginess was not advantageous in resisting the formation of transverse fissures by diffusion of the internal strains. The most defective steel in fissured rails has been found in those rails that resisted the formation of transverse fissures the longest intervals of time in the track. So far as this evidence goes, it does not increase our anxiety as to the detrimental effect of seaminess as a factor in leading to the formation of transverse fissures.

Concerning the influence of longitudinal seams, streaks, or laminations upon the development of transverse fissures, it is not known that they exert any direct influence. The iron-phosphide streaks, forming the subject matter of the paper under discussion, are oriented in the same manner as other streaks; they are parallel to the length of the rail, in which direction the influence of streaks is not materially felt on the tensile properties.

The American Railway Engineering Association has published one or two reports upon interior fissures, in which longitudinal seams were referred to. The distinction will be kept in mind between such manifestations, which are commonly called seams and transverse fissures, the similarity in captions tending toward confusion. Puddled iron may be referred to as an example of seamy fibrous metal, oriented longitudinally, upon which experiments have been conducted on repeated stresses. Wrought-iron bars, in terms of the elastic limits, have shown results superior to those of high-carbon and medium-carbon steels. A wrought-iron bar endured a fiber stress 36 per cent. in excess of its elastic limit some eight times longer than a medium-carbon steel endured a fiber stress less than 2 per cent. in excess of its elastic limit.

In the minds of some there are features associated with rails that are regarded as causes of the formation of transverse fissures, which upon analysis appear as deterrents. To the writer, it seems preferable to assign as causes of the formation of transverse fissures those factors that are known to lead to rupture rather than to pin faith upon features that are still obscure and the correlation of which with transverse fissures has not yet been established.

Metals and Alloys from a Colloid-chemical Viewpoint

Discussion of the paper by JEROME ALEXANDER, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 427.

WILDER D. BANCROFT,* Washington, D. C. (written discussion†).—In two-phase systems there are three possibilities and Mr. Alexander has only considered two. We may have the first phase the internal one and the second the external one; we may have the first phase the external one and the second phase the internal one; and we may have both phases continuous. This last case occurs when we have a roll of wire fencing standing in the air; the wire is continuous and so is the air. It is quite probable that this case occurs very often in alloys and it it, therefore, important that it should not be overlooked. With gold

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† Received Jan. 31, 1919.

containing a little bismuth, the bismuth forms a coating around the grains of gold and consequently makes a brittle alloy having a low conductivity; this is one of the cases covered by Mr. Alexander's classification. The important nature of the external phase is shown very clearly in some work by C. G. Fink published some years ago. He took the same mixtures of metallic tungsten and alumina and compressed them to solid masses, the only difference being that the tungsten was relatively coarse in one case and relatively fine in the other. When the tungsten was relatively coarse, the fine alumina particles coated the coarser tungsten particles and he obtained a white mass that does not conduct electricity. When the tungsten particles were relatively fine, they coated the coarser alumina particles and he got a black mass that conducts electricity.

It seems a pity to bring up an analogy between alloys and jellies, because the alloy is the simple case and the jelly is the complicated one. In the case of the alloy the mass is always crystalline; we can determine easily the composition of the two phases and it is not difficult to ascertain whether we are dealing with external and internal phases, or what I call an interlaced system. In the case of a jelly, both phases are amorphous; we do not know the composition of either phase and we do not know the structure. It may be advisable some day to discuss jellies with reference to alloys, but it is certainly a step backward to discuss alloys with reference to jellies.

Petroleum Hydrology Applied to Mid-Continent Field

Discussion of the paper by Roy O. Neal, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 145, January, 1919, p. 1.

G. Sherburne Rogers,* Washington, D. C. (written discussion†).—Mr. Neal's paper on the petroleum hydrology of the Mid-Continent district is a welcome contribution on a subject concerning which none too much is known; it is, I think, the first published description of the chemical character of the oil-field waters of the great Mid-Continent area. When studying the oil-field waters of the California fields several years ago, the differences in chemical composition between waters occurring at various horizons seemed to be sufficient to enable the operators to use water analyses as a basis for determining the source of the water flooding a well; and it is gratifying to find that Mr. Neal has arrived at a similar conclusion.

As Mr. Neal points out, the Mid-Continent waters are very different in character from those of the California fields, and casual inspection

* Geologist, U. S. Geological Survey. † Received Jan. 27, 1919.

would seem to indicate that the laws governing their variation are diametrically opposed to those that seem to have operated in California. In the Mid-Continent fields, the upper waters are highly concentrated solutions of sodium, calcium, and magnesium chlorides and are practically lacking in sulfates; whereas the waters underlying the main producing oil sands are much less concentrated, contain sulfates, and closely resemble ocean water. In the California fields, the waters above the oil sands are moderately strong solutions of sodium, calcium, and magnesium sulfates, with carbonates and chlorides in minor proportion; whereas the waters close to the oil sands or below them are generally much more concentrated and much higher in chlorides, but are invariably lacking in sulfates. Broadly speaking, therefore, concentration increases with depth in California, but in the Mid-Continent field it diminishes; sulfates decrease and disappear as the oil sand is approached in California, but in the Mid-Continent field they are absent above the main oil sand and appear only beneath it.

The first point of difference, concentration, is evidently due to the great difference in geologic conditions that distinguishes the two areas. The fields of San Joaquin Valley, California, are located in the foothills about 500 ft. (152 m.) above the center of the valley, and as the formations dip steeply and outcrop close to the fields considerable surface water enters the rocks and drains down toward the valley. Drainage is impeded, especially in the deeper beds, by a series of anticlines which separate the fields from the main valley, and the troughs back of these anticlines constitute traps from which apparently the original connate water has never completely drained. The upper waters are therefore similar to the normal ground-water in any semi-arid region, their salts being derived from the rocks through which they pass; the deeper waters, however, are partly or largely connate in character and in some localities closely approach ocean water in density. In the Mid-Continent area, on the other hand, the fields are located far from the outcrop of the producing sands and the dips are very gentle; meteoric waters penetrate only to shallow depths and the underground circulation beneath is exceedingly sluggish. The very high concentration of these waters may be due to the fact that they have remained practically stagnant for long geologic periods and that the rocks with which they have come in contact contained disseminated salt and other chlorides. The theory, advanced by Mills and Wells, that ascending hydrocarbon gases exert an appreciable drying effect on underground waters, and thus increase their concentration, may also be applicable. The decidedly lower concentration of the waters beneath the deepest oil sand in the Augusta and Eldorado fields may be explained by supposing that these waters have not come into contact with salt; that their circulation at some remote time was freer than that of the waters above them has ever been; or that, since they underlie the deepest

known oil sand, they have not been subjected to the drying effect of ascending hydrocarbon gases and therefore retain their original density.

The second point of difference between the Mid-Continent and California waters, variation in sulfate, is probably also due to difference in geologic conditions. In the California fields, the shallow waters are high in sulfate, those close above the oil zone contain less sulfate but generally some sulfide, those in and below the oil zone carry neither sulfate nor sulfide. The theory that the sulfates in this area were reduced to sulfides (including hydrogen sulfide) through the action of certain hydrocarbons seems plausible, therefore. In the Mid-Continent field, Mr. Neal states that the waters above the main oil sands, which in the fields described lie at about 2500 ft. (760 m.), are sulfate free, whereas those beneath them contain sulfate; but he does not take into consideration the presence of higher and commercially less important oil and gas horizons. Thus, in the Eldorado field, considerable oil is produced from a sand at about 600 ft. (182 m.) and there are prolific gas sands at about 900 and 1200 ft.; in the Augusta field, the 600-ft. horizon carries gas and there is another and more important zone of gas sands between 1400 and 1600 ft.; and in the Blackwell field, gas is encountered at numerous horizons between 225 and 3275 ft. and some oil in several sands between 2000 and 3350 ft. The waters lying above the main oil sands in these fields, therefore, cannot be considered top waters in the sense in which I used the term in describing California conditions—as waters unaffected by oil or gas—and the absence of sulfate in these upper waters is thus in accord with the theory that sulfates are eliminated by the reducing action of hydrocarbon materials. The absence of sulfate in the waters beneath the oil sands in California is thought to be due to the fact that the oil and the deeper waters migrated together from unconformably underlying formations. In the Mid-Continent field, there is no evidence of extensive upward migration and the presence of sulfate beneath the oil sands is not, therefore, an argument against the sulfate reduction theory. Nevertheless, despite the strong evidence in favor of this theory to be found in the California fields, I would not venture to apply it in the Mid-Continent district without further evidence. The oils of the two regions are very different in character and the reaction may be induced only by some constituent present in California oil and absent in the Mid-Continent variety. Moreover, the fact that the ratios of calcium to magnesium are distinctly smaller in the upper Mid-Continent waters than in the deeper ones suggests that most of the sulfate, in conjunction with calcium, has been precipitated out as gypsum. These problems cannot well be solved until more extensive studies of the Mid-Continent and Appalachian oil-field waters have been made.

It is interesting to note that the upper waters analyzed by Mr. Neal are not true bitterns, despite their concentration, and that except for the

absence of sulfate they bear a general resemblance in properties to ocean water. In this respect they differ from most Appalachian oil-field waters and many other strong natural brines, which are characterized by high proportions of calcium and magnesium chlorides. The deeper water, which is almost identical in properties and in density with ocean water, is also highly interesting. The discovery of a Pennsylvanian fossil water so similar to the water of the ocean today raises a difficult problem for those who contend that connate water cannot long remain in the rocks without losing its original character. On the other hand, it certainly does not support the views of A. C. Lane and others who have attempted to trace variations in the composition of the ocean through geologic time, and who suggest that the age of a fossil water may be determined roughly from its composition.

The analyses presented by Mr. Neal appear to have a bearing also on the search for deeper oil sands in the Augusta and Eldorado fields. The fact that the waters within the general productive zone are several times as concentrated as those directly beneath it indicates a distinct change in conditions at the base of the deepest known oil sand. The geologic nature and cause of this change are not clear, but the mere fact that a change exists suggests that the true base of the oil-bearing zone has been reached and that no deeper sands will be found. The appearance of sulfate in these deeper waters may have a similar significance, though, for the reasons mentioned, I should not attach much weight to variation in sulfate until the waters of this region have been more extensively studied.

Mr. Neal's statement, that the waters of each pool probably have their own peculiarities and that no attempt to use water analyses in practical oil-field work should be made until the local variations had been studied, is thoroughly warranted. Conditions in the Mid-Continent field are very different from those in California, and the waters of both districts differ from those of the Appalachian and of the Gulf Coast fields. In all oil fields, the underground circulation is naturally restricted and the waters are usually salty; but except in this regard there is no more reason to assume that all oil-field waters are alike than to assume that all river waters are similar. However, as most of the world's oil is produced from Tertiary and Cretaceous formations under conditions resembling those in California, rather than those in the Paleozoic fields of the United States it is probable that oil-field waters the world over have a general resemblance to those in California. This inference is supported by a study of the analyses of such oil-field waters from Russia, Roumania, Galicia, Egypt, India, etc. as I have been able to collect.

A Comparison of Grain-size Measurements and Brinell Hardness of Cartridge Brass

Discussion of the paper of W. H. BASSETT and C. H. DAVIS, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 145, January, 1919, p. 57.

ARTHUR PHILLIPS,* Bridgeport, Conn. (written discussion†).—It is to be regretted that the very valuable paper by Messrs. Bassett and Davis did not appear in the early war period. The data presented would have been of inestimable service to inspectors of cartridge brass who, admittedly, had little or no knowledge regarding the relation of grain size to temperature of anneal, and no real appreciation of the significance of the Brinell hardness test. The paper is of considerable interest to metallurgists also.

WALTER R. HIBBARD,‡ Bridgeport, Conn. (written discussion§).—The writer has carefully studied Messrs. Bassett and Davis's paper with considerable interest, inasmuch as our laboratory has tested cartridge brass by means of a Brinell machine. In March, 1917, at the suggestion of the Technical Department of the American Brass Co., we started a comparison of grain-size measurements and Brinell hardness of cartridge brass with a gage of 0.1 in. or greater. This was continued until March, 1918, when we adopted the Brinell hardness test as standard for brass 0.1 in. gage or greater, and discontinued grain-size measurements upon this metal. The data collected during the test showed that the Brinell hardness indicated more accurately how the metal acted in actual working operations. It was also more reliable because two manipulators check themselves closer by the Brinell test than by the grain-size measurements. It also consumed less time in making the tests. Alfred V. de Forest, formerly assistant research engineer of our laboratories, has described the apparatus and some of the checking results in a paper read June, 1918, before the American Society for Testing Materials.[1] The writer hopes that a more satisfactory method for testing cartridge brass and gilding in gages thinner than 0.1 in. may be devised than the present method of grain-size measurements.

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[1] *Proc.* Amer. Soc. Test. Mat. (1918) **18**, Pt. 2, 449.

† Received Jan. 18, 1919.

§ Received Jan. 30, 1919.

Employment of Mine Labor

Discussion of the paper of HERBERT M. WILSON, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 145, January, 1919, p. 83.

W. D. BRENNAN,* Cheyenne, Wyo. (written discussion†).—My experience has been that, where possible, it is preferable for each foreman to employ his own men, rather than to have them handled through an employment bureau. The fact that each foreman comes into direct contact with the man before he is put to work gives him an opportunity to choose, at certain times, the kind and class of men that he wishes. Where possible, after a man is employed he is sent to a central office where a complete history of each individual is kept on a card. If a man has previously been in the employ of the Company, his history can be obtained from this card, and if for any reason he is not wanted he can be refused work at the time he reports to the central office.

In connection with Workman's Compensation costs, we in Wyoming feel that although the rates of compensation paid may in some cases be rather low our law works satisfactorily. As the State and the number of employees are small, compensation cases are handled through Judges of the various District Courts. In the State Treasurer's Department, a few clerks were added to look after the handling and issuing of warrants and compiling of statistics. Most of the large employers have an arrangement by which a joint claim and assent, specifying the amount of compensation due, is made up by the employer and signed by the workman. This is forwarded to the Judges so that personal investigation of individual cases is not necessary. In this manner, compensation is promptly received and overhead expenses of operation of the law is kept at the minimum.

The law requires each employer to pay into the State Treasury, for the benefit of the industrial fund, a sum equal to 1.5 per cent. of the money earned by each employee, engaged during each calendar month of such employment. Each employer contributes monthly, unless the sum heretofore contributed, after deducting all payments made on account of injuries to his employees, shall equal a full 1.5 per cent. of his annual pay roll, computed by multiplying his current monthly pay roll by twelve, and shall likewise be not less than ($5000). It has been found during the years that this law has been in effect, that a number of the larger employers have been exempt from payment for from five to eight months per year, so that in some cases, even in coal mines, industrial insurance has cost less than 0.75 per cent.

The question of relationship between employer and employees is one where personal friendship is of the utmost importance. We of the

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* Asst. Gen. Mgr., Union Pacific Coal Co. † Received Jan. 24, 1919.

West probably have, or at least feel that we have, a greater freedom than exists in some other parts of the country, so that we possibly come in closer contact with the employees than is possible in some other localities. This, in a number of cases, has been the means of avoiding serious trouble. The closer the personal relations between the employer and the employee, the easier it is to get together and talk over difficulties and questions that are constantly arising. The fact that the employees are allowed to state their grievances and have an opportunity to be shown the employers' point of view will, in many cases, go a long way toward keeping relations friendly.

Will L. Clark, Riverside, Cal. (written discussion*).—In the large operating metal mines of the western part of the United States the situation is one of much complexity, due to the plan of wage schedules effective during the European war and based on the average monthly price per pound of copper. It would have been much better for the western mining industry, in general, if an allotment had been made from surplus annual earnings, for it seems most desirable that workmen should have some interest in an operating company experiencing a good year and producing an amount sufficient to allot each workman, having a clear record, $100, or more, annually.

Detailed attention to welfare provisions is now the practice, in all western mining camps of the large copper companies. The question of uniform wage schedules should be formulated promptly; and during its consideration with employees, there might be included the preliminary discussion of uniform workmen's compensation plan, including sickness and accident allowances. It is a serious reflection on the ability of the executives of western metal mining companies that they have not devoted time and concerted effort to reach an agreement with employees as to a sensible wage schedule and compensation for sickness and accident; but instead have run along under a haphazard temporizing policy. This necessity once met and arranged for, the mining camps as now conducted, free from the saloon evil, offer high wages and fine climatic and, generally, good living conditions.

The best opportunities for investments, where one is able to form first-hand opinion, are producing mines or speculative chances in new prospects being opened in a miner-like and proper business manner, as differentiated from the wild-cat, stock-selling promotions, also the products from nearby farm lands are assured of an exceptional market and many miners invest and retire to country life.

This digression from the main subject, which has been well stated by Mr. Wilson, is to call attention to the opportunity that exists for young Americans in mining and related occupations. The metal mines and ore-reduction plants offer work that is interesting and not arduous.

* Received Jan. 31, 1919.

The young Americans appear recently to have taken up mining work, not as a vocation but as an opportunity to travel, jumping from place to place, while the foreigner, appreciating good wages, has held on, until the proportion now engaged is surprisingly large, in some mines 80 per cent. An observer returning from the battle front in France said there were three things noticeable about the American soldiers, in camp: First, they were regularly hungry; second, broke; third, always wishing they were somewhere else. The last is true of our young men with reference to all ordinary or common labor. A large proportion of the orchard and garden workers in California are Japanese, Chinese, Portuguese, Mexicans, and a few Indians and other native Americans. American youths have not displayed sufficient persistence to make producing war gardens. Can they be induced to take up mining and other ordinary vocations and, if so, how is efficient work to become the rule and provide for the continuance of high wages? In a recent article, Mr. Mitke says "Time studies will lead to mutually advantageous results, but in the minds of workmen, unfortunately, the idea of time studies is so closely associated with speeding up the work that they are inclined to look on them with suspicion."

One of the reasons for this belief is that the men are not informed and given opportunity to coöperate in the whole study. Clearly a better understanding with the workmen can be arranged and every one, by meetings, lectures, and examples, shown the advantage to him, and his class, of accomplishing a fair day's work, without waste of effort. Every local superintendent and manager knows how almost maddening it has been to observe unskilled and time-killing laborers, and to feel, since the foreman or boss is no longer a driver, that there was not available any relief. Now the immediate necessity of bettering the labor situation should evolve this and conferences be arranged to formulate agreements.

Another phase, which Bolshevism has made immediate, is brought out in the annual report of the Secretary of the Interior, Hon. Franklin K. Lane, for 1918. He says: "To the necessity for more thorough education of the people all countries have become keenly alive. As we move further and further from the war, we will discover much that we do not now see. But this one thing stands out more plainly than ever before, that this world is to belong to the workers, those who do and those who direct the doing. Not merely to those who drive the nail or lay the brick, but also to those who have come to a higher capacity through education and large experience, the men of scientific knowledge, of skill in the arts, of large organizing capacity, ease, and sheltered repose will come only to those who themselves have earned it." In the opinion of the writer, it is of the greatest moment that wage schedules for metal mines be formulated and all the time and effort required be devoted to the adjustment to practical working and living conditions.

INDUSTRIAL SECTION

This department is devoted to material concerning the products or operations of manufacturers, which, in the estimation of the Editor, is of news value to the mining and metallurgical field but does not come within the scope of the main editorial section of the Bulletin.

Manufacturers are invited to submit to the Editor items descriptive of new equipment or processes, large or significant installations, and similar material of news character. If found available, items thus furnished will be published in this section without charge, subject to such editorial revision and condensation as may be necessary.

In cases where illustrations are required, cuts of the proper size should accompany the text matter.

CRANE PROTECTIVE PANELS

The crane protective panels, manufactured by the General Electric Co., Schenectady, N. Y., provide overload and under voltage protection for the individual motors as well as for the crane as a whole. They are equally well adapted for use with manual or magnetic contactor control equipments. The panels are compact, enabling them to be mounted in the crane cab along with the emergency switch, manual controllers, and master switches, all within easy reach of the operator. They are made for three-, four-, and five-motor cranes, with a maximum capacity of 300 hp.. For more than five motors or more than 300 hp., two panels are used.

QUARRYING SANDSTONE IN MINNESOTA

The plant of the Kettle River Co., at Sandstone, Minn., produces about 10,000 cu. yd. of Kettle River sandstone each year at the rate of 50 cu. yd. a day, which it handles by means of derricks, a system of railroad tracks, cars and locomotives, and a recently installed Lidgerwood cableway. This cableway has a 650-ft. span and a 5-ton capacity. It serves the crushing plant with stone from the quarry. After material has passed through the crusher, it goes to storage bins from which it can be emptied into railway cars. Building material, etc., is loaded on cars by means of derricks. The plant is fitted out with Leschen Wire Rope. *Hercules* (Red-strand) is the choice for hoisting and galvanized cast steel for guys.

BEATS THE SWEATER

We learned a good many things from our war experience. One was that the old-fashioned sweater was not the best protection from exposure for the soldier; it was warm enough but did not keep out the rain. So the trench vest was developed to replace the sweater and is both warm and waterproof. Anyone who can use shears and needle and thread can make one in a couple of hours. The material used is a medium-weight fabrikoid (a leather substitute) having a napped back, and the vest weighs but a few ounces. It requires no lining, the napped back of the material serving that purpose. It is as warm as a sweater, is dirt, grease, water, and stain-proof, and is washable with soap and water. It is much more durable than a woolen sweater and not nearly so likely to catch on nails and tear.

CLEARING LAND WITH T. N. T.

The U. S. Government is said to have a large amount of trinitrotoluol (commercially called T. N. T.) on hand. In fact, the sudden ending of the war left in the magazines more of this explosive than the officials know what to do with. It has been suggested that some of it can be used for blasting the stumps, boulders, and ditches on the land to be sold by the Government to the discharged soldiers. T. N. T. is a quick and strong explosive—about equal in strength, in fact, to 40 per cent. ammonia dynamite, which is the most generally used explosive for land clearing. It is non-freezing, but is very insensitive and requires a No. 8 blasting cap to detonate it successfully. This cap is considerably more expensive than the No. 6 cap, generally used to fire charges of 40 per cent. dynamite. Dynamite works all right in wet or damp soil. T. N. T. is very hydroscopic. It takes but a very little moisture to render it non-explosive. Therefore, if it is to be used for land clearing or drainage in place of dynamite, extreme care must be exercised to keep it dry.

TRADE CATALOGS

(Under this heading will be listed such catalogs or other advertising literature as may be received during the preceding month. Contributors should address their material to Engineering Societies Library, 29 West 39th St., New York.)

A. M. Lockett & Co., Ltd. New Orleans.
Lockett oil-burning apparatus. Automatic fuel oil pumping set. 1919.

Eastman Kodak Co. Rochester, N. Y.
Price list Eastman organic chemicals. January, 1919.

General Electric Co. Schenectady, N. Y.
CR 4409-B1 Crane protective panels for direct-current motors.
G-E type CP circuit breakers.
G-E self-contained solenoid-operated circuit breakers.
Line material and rail bonds for mine and industrial haulage. December, 1918.

Heine Safety Boiler Co. St. Louis, Mo.
Boiler Logic.

Herold China and Pottery Co. Golden, Col.
Coors U. S. A. Chemical and scientific porcelain. Feb. 1, 1919.

Quigley Furnace Specialties Co. New York.
Bulletin No. 10. Powdered coal "flows like water." October, 1918.

Royal Copenhagen Porcelain. New York.
Royal Copenhagen chemical and scientific porcelain.

Sullivan Machinery Co. Chicago.
Bulletin 72-C. The Sullivan drill sharpener, for hammer-forging drill bits and shanks.
——— 75-D. Sullivan "WA-5" air compressor.
——— 75-E. Sullivan "WB-3" air compressors.
——— 75-G. Sullivan small, belt-driven air compressors.
——— 75-I. Sullivan portable mine-car air compressors.

Supplee-Biddle Bulletin. Monel Metal. Vol. 5, No. 9.

Thwing Instrument Co. Philadelphia.
Thwing pyrometers. Catalog No. 9.

THE MINING AND METALLURGICAL INDEX

January, 1919

The Engineering Societies Library is prepared to supply the original, or a copy, translation, or abstract of any paper mentioned in the following index, at the following rates:

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In the following Index, volume numbers are given in heavy-faced figures, page numbers in light-faced figures. Approximate number of words is stated.

MINERAL RESOURCES

(Except Petroleum and Gas. See also Mining Geology and Mining Practice.)

ALASKA'S mineral development during 1918. J. L. McPherson, *Min. & Sci. Pr.* (Jan. 11, 1919) **118**, 45–8. 2500 w.

ALASKA'S mineral production reported by Geological Survey. *Alaska R. R. Rec.* (Jan. 7, 1919) **3**, 70–1. 2000 w.

ALUMINUM industry in 1918. *Metal Ind.* (Jan., 1919) **17**, 2. 900 w.

ANTHRACITE industry in 1918. Edward W. Parker, *Coal Age* (Jan. 16, 1919) **15**, 108–10. 2200 w.

ANTIMONY in 1918. K. C. Li, *Engng. & Min. Jnl.* (Jan. 11, 1919) **107**, 64–5.. 1000 w.

ASBESTOS industry. *Engng. & Min. Jnl.* (Jan. 11, 1919) **107**, 51. 900 w.

AUSTRALASIA in 1918. W. P. Geary, *Engng. & Min. Jnl.* (Jan. 11, 1919) **107**, 121–3. Gold, tin and copper production.

BRIEY iron industry. La industria del fierro y la cuenca de Briey. *Bol. de Minas.* (Sept. 30, 1918) **10**, 117–21. 2200 w.

BRITAIN'S mineral resources. *Quarry* (Jan., 1919) **24**, 7–9. 2000 w. From report of Sir Lionel Phillips.

BRITISH Empire, Imperial Institute map of the chief sources of metals in the. *Geol. Mag.* (Dec., 1918) **5**, 543–6. 1500 w.

CADMIUM supply of the United States. C. E. Siebenthal, *Bull.* A. I. M. E. (Dec., 1918) 1752–9. 2500 w.

CHILEAN nitrate industry, Influence of American developments on the. *Am. Fertilizer* (Jan. 4, 1919) **50**, 50–2. 800 w. From *Chem. Tr. Jnl.*, London.

CHROME in Africa, Big deposits of. *Metal Rec.* (Dec., 1918) **4**, 405. 300 w.

CHROME ore in 1918. F. F. Sharpless, *Engng. & Min. Jnl.* (Jan. 11, 1919) **107**, 81–2. 700 w.

CHROME sands on the Pacific coast. Justice F Grugan, *Chem. & Met. Engng.* (Jan. 15, 1919) **20**, 79–81. 2000 w.

COAL in Spitsbergen. W. H. Wilcockson, *Geol. Mag.* (Dec., 1918) **5**, 529–32. 1800 w.

COAL—now and next year. C. E. Lesher, *Coal Age* (Jan. 16, 1919) **15**, 99–104. 3000 w.

COAL-producing states during 1918, Activities in different. *Coal Age* (Jan. 16, 1919) **15**, 82–8. 20,500 w. Mostly mine inspectors' reports from different states.

COKE industries during 1918, Connellsville and by-product. B. E. V. Luty, *Coal Age* (Jan. 16, 1919) **15**, 143–4. 2000 w.

COPPER for 1918. *Engng. & Min. Jnl.* (Jan. 11. 1919) **107**, 46. 600 w.

COPPER industry in 1918, Lake Superior. James McNaughton, *Engng. & Min. Jnl* (Jan. 11, 1919) **107**, 50–1. 600 w.

GERMAN iron and steel manufacturers, Secret Memorandum of the. *Iron & Steel Tr. Jnl.* (Dec. 28, 1918) 712–3. 2500 w.

GOLD and silver in 1918. *Engng. & Min. Jnl* (Jan. 11, 1919) **107**, 41. 400 w.

GOLD in Victoria, Discovery of. *Indus. Austral.* (Dec. 12, 1918) **60**, 938. 700 w.

GOLD mining industry, To save our. *Indus. Austral.* (Dec. 19, 1918) **60**, 981. 1000 w. Edit.

GOLD production in Western Australia. *Indus. Austral.* (Aug. 29, 1918) **60**, 294. 1000 w.

GOLD, Report of the committee on. *Min. & Sci. Pr.* (Jan. 4, 1919) **118**, 9–12. 5000 w.

GRAPHITE in 1918. *Engng. & Min. Jnl.* (Jan. 18, 1919) **107**, 147–8. 1500 w.

GRAPHITE in 1918, Alabama. W. F. Prouty, *Engng. & Min. Jnl.* (Jan. 25, 1919) **107**, 194–5. 2000 w.

GRAPHITE industry, Canadian. Hugh S. Spence, *Chem. & Met. Engng.* (Jan. 15, 1919) **20**, 81. 500 w. Abstract from *Rept.* Canad. Dept. Mines, 1917.

IRON and steel, Tremendous blow to German. *Blast Fur. & Steel Plant* (Jan., 1919) **7**, 12. 800 w.

IRON hill, Westralia's. *Indus. Austral.* (Dec. 19, 1918) **60,** 1009. 1000 w. From report of Government Geologist. Describes deposits.

IRON of Lorraine. *Queensland Govt. Min. Jnl.* (Dec., 1918) **19,** 564. 800 w. From *Min. & Sci. Pr.*, Sept. 21, 1918.

IRON ore deposits in Savoy. A. Bordeaux. Les gisements de fer de la Savoie. *Bull.* Compt. Rend. Mens. Soc. de Indust. Min. (3d No., 1918) **14,** 50–65. 15 p.

IRON ore district wins war honors. *Iron Tr. Rev.* (Jan. 16, 1919) **64,** 201–6. 2500 w. Lake Superior mines.

IRON ores of British Columbia. R. C. Campbell-Johnston, *Min. Jnl.* (Dec. 28, 1918) **123,** 760–1. 3000 w.

LEAD. *Engng. & Min. Jnl.* (Jan. 11, 1919) **107,** 52. 600 w. Statistics of production.

LEAD and zinc in the Joplin district. Jesse A. Zook, *Engng. & Min. Jnl.* (Jan. 11, 1919) **107,** 59. 800 w.

LEAD district, The southeastern Missouri. H. A. Wheeler, *Engng. & Min. Jnl.* (Jan. 11, 1919) **107,** 132–3. 1800 w.

LEAD industry. C. Dantin, L'industrie du Plumb. *Métaux, Alliages & Machines* (Nov., 1918) **11,** 1–6. 5000 w.

LIGNITE experts tour U. S. *Chem. Engr* (Dec., 1918) **26,** 496. 400 w. Canadian scientists survey resources.

MAGNESITE and zirconia. *Iron Age* (Jan. 30, 1919) **103,** 304. 500 w. From London *Times.* Used for refractory purposes, output, etc.

MAGNESITE in Washington. *Alaska & Northwest Min. Jnl.* (Nov., 1918) **12,** 97–100. 5000 w.

MANGANESE at Kandanga. B. Dunstan, Queensland Govt. Min. Jnl. (Dec., 1918) **19,** 558. 500 w.

MANGANESE deposits of East Tennessee. G. W. Stose and F. C. Shrader, *Resources of Tennessee* (Oct., 1918) **8,** 235–324.

MANGANESE, Developing Arkansas. *Iron Tr. Rev.* (Jan. 30, 1919) **64,** 328–30. 1500 w.

MANGANESE in 1918, Cuban. John B. Stewart, *Engng. & Min. Jnl.* (Jan. 25, 1919) **107,** 196. 500 w.

MANGANESE industry, Deplorable condition of western. *Min. & Oil Bull.* (Dec., 1918) **5,** 19–20. 900 w.

MANGANESE ore in 1918. *Engng. & Min. Jnl.* (Jan. 11, 1919) **107,** 77–8. 1200 w.

MANGANESE ore in East Tennessee. Henry V. Maxwell, *Engng. & Min. Jnl.* (Jan. 18, 1919) **107,** 149. 700 w.

MANGANESE ore mines in Northwest. *Iron Tr. Rev.* (Jan. 23, 1919) **64,** 273–4. 2000 w.

MERCURY in Europe, Minor occurrences of Roland Sterner-Rainer, *Chem. & Met. Engng.* (Jan. 15, 1919) **20,** 82–4. 2500 w. Translated from *Osterreichische Zeit. für Berg. und Huttenwesen.*

MIAMI district, Oklahoma. A. E. Bendelari, *Engng. & Min. Jnl.* (Jan. 18, 1919) **107,** 145. 800 w. Zinc production.

MINERALS in the disputed Chile-Peru territory. *Min. & Sci. Pr.* (Jan. 18, 1919) **118,** 78. 700 w.

MINERALS, Economic limits to domestic independence in. George Otis Smith, *U. S. Mineral Resources,* 1917. Part I. (Dec. 28, 1918) 1–6. 3500 w.

MINERALS, International control of. Courtenay De Kalb, *Min. & Sci. Pr.* (Jan. 18, 1919) **118,** 75–7. 2500 w.

MINERALS, International control of. C. K. Leith, *U. S. Mineral Resources,* 1917. Part I. (Dec. 31, 1918) 7–16. 4500 w.

MINERAL resources, British. *Ironmonger* (Dec. 21, 1918) **165,** 58. 800 w. Edit.

MINES and the mining market in 1918. *Min. Jnl.* (Jan. 4, 1919) **124,** 1–3. 2800 w. Reviews points of interest.

MINING in 1918, Labor and. F. F. Sharpless, *Engng. & Min. Jnl.* (Jan. 11, 1919) **107,** 66–8. 1500 w.

MINING in Colorado in 1918. George E. Collins, *Engng. & Min. Jnl.* (Jan. 18, 1919) **107,** 152–4. 3000 w. Districts reviewed. Gold, zinc, telluride.

MINING in Ontario in 1918. Thomas W. Gibson, *Engng. & Min. Jnl.* (Jan. 11, 1919) **107,** 108–10. 2500 w.

MINING in Manitoba during 1918. R. C. Wallace, *Bull.* Canad. Min. Inst. (Jan., 1919) 17–20. 1000 w.

MINING in Mexico today. *Engng. & Min. Jnl.* (Jan. 25, 1919) **107,** 175–7. 2000 w.

MINING in the United States in 1918, General review of. *Engng. & Min. Jnl.* (Jan. 11, 1919) **107,** 103–7. 5500 w.

MINING in Utah in 1918. Edward R. Zalinski, *Engng. & Min. Jnl.* (Jan. 25, 1919) **107,** 178–83. 5000 w.

MOLYBDENUM ores in 1918. *Engng. & Min. Jnl.* (Jan. 11, 1919) **107,** 82–3. 800 w.

MYSORE State. Department of mines and geology. *Records,* **16,** 1–50. Annual report for the year 1916–7.

NATURAL resources as emphasized by the lessons of the war, The need of conservation of our vital and. Henry Sturgis Drinker, *Science* (Jan. 10, 1919) **49,** 27–31. 3500 w.

NITRATE industry, Chilian. J. A. H. Clark, *Bull.* Pan Am. Union (Nov., 1918) **47,** 645–63. 4500 w.

ONTARIO, The year in. Thomas W. Gibson, *Bull.* Canad. Min. Inst. (Jan., 1919) 11–7. 2500 w. Reviews the year 1918.

ORES and metals, Uncommon. H. C. Mayer, *Engng. & Min. Jnl.* (Jan. 11, 1919) **107,** 124–5. 1800 w.

OUTPUT of coal, Increasing the. John Gibson, *Coll. Guard.* (Dec. 13, 1918) **116,** 1243–5. 6000 w.

PHOSPHATES in Spain and North Africa. *Am. Fertiliser* (Jan. 18, 1919) **50,** 58–62. 1500 w.

POTASH deposits, Alsace. *Iron & Coal Tr. Rev.* (Dec. 20, 1918) **97,** 704. 1200 w. From paper by Paul Kestner.

POTASH in the United States of America, Production of. *Engng.* (Dec. 20, 1918) **106,** 704–5. 2500 w.

POTASH industry of Alsace. *Engng.* (Dec. 27, 1918) **106,** 734. 800 w.

POTASH mines, Alsatian. *Am. Fertiliser* (Jan. 4, 1919) **50,** 37. 600 w.

POTASH mines and works, Alsatian. *Am. Fertiliser* (Jan. 18, 1919) **50,** 35–7. 2000 w. From *Chem. Tr. Jnl.*, London. The German and French views.

POTASH producing company getting ready for operation. E. M. Allison, Jr., *Salt Lake Min. Rev.* (Dec. 30, 1918) **20,** 17–9. 2500 w.

PRODUCTION (coal) in Colorado in 1918, and the outlook for the coming year. F. W. Whiteside, *Coal Age* (Jan. 16, 1919) [illegible] 141–2. 1200 w.

QUEBEC mining industry during the year 1918. T. C. Denis, *Bull.* Canad. Min. Inst. (Jan., 1919) 8–11. 1000 w.

QUICKSILVER in Texas in 1918. W. D. Burcham, *Engng. & Min. Jnl.* (Jan. 18, 1919) **107**, 145–6. 800 w.

REFRACTORY materials of South Wales. J. Allen Howe, *Quarry* (Jan., 1919) **24**, 11–5. 3500 w.

ROCK salt in Nova Scotia, Notes of a discovery of. L. Heber Cole, *Canad. Min. Jnl.* (Jan. 8, 1919) **40**, 8–9. 1000 w.

SILVER in 1918. Edward Brush, *Engng. & Min. Jnl.* (Jan. 11, 1919) **107**, 41–3. 2000 w.

TRANSVAAL mining in 1918. H. F. Marriott, *Engng. & Min. Jnl.* (Jan. 11, 1919) **107**, 118–21. 3500 w.

TUNGSTEN industry in 1918. George J. Young, *Engng. & Min. Jnl.* (Jan. 11, 1919) **107**, 78–80. 2000 w.

UNITED States in 1918, Coal and coke production in. *Mfrs. Rec.* (Jan. 9, 1919) **75**, 92. 1000 w.

UNITED States, The coal situation in the. Charles R. Van Hise, *Universal Engr.* (Oct., 1918) **28**, 58–64. 3500 w.

WAR minerals meeting at Washington. Courtenay De Kalb, *Min. & Sci. Pr.* (Jan. 11, 1919) **118**, 41–3. 3500 w.

WORLD'S iron and steel industry, Future American influence in regenerating the. *Blast Fur. & Steel Plant* (Jan., 1919) **7**, 2–10. 8000 w.

ZINC. *Engng. & Min. Jnl.* (Jan. 11, 1919) **107**, 57–8. 900 w. Statistics of production.

ZIRCONIA as a refractory. E. H. Rodd, *Sci. Am. Sup.* (Jan. 25, 1919) **87**, 54. 2200 w. From *Jnl.* Soc. Chem. Ind.

MINING GEOLOGY AND MINING PRACTICE

(See also Mineral Resources)

ACCIDENTS in electric working in Prussian mines during 1917. Bemerkenswerte Unfälle in elektrischen Betrieben auf den Bergwerken Preussens in Jahre 1917. *Ztsch. Berg. Hütten u Salinenwesen* (July 23, 1918) **28**, 187-95.

AIR BLASTS in the Kolar gold field, India. E. S. Moore, *Bull.* A. I. M. E. (Dec., 1918) 1765–6. 500 w. Author's reply to discussion.

ALASKA in 1917, Gold, silver, copper and lead in. G. C. Martin, *Alaska Northwest. Min. Jnl.* (Dec., 1918) **12**, 121–5. 4800 w. Review.

BLACKDAMP, Origin of. J. Ivon Graham, *Queensland Govt. Min. Jnl.* (Dec., 1918) **19**, 568–71. 4000 w. Read before Inst. Min. Engrs.

BLASTING costs in American quarries. Oliver Bowles, *Engng. & Contr.* (Jan. 15, 1919) **51**, 56–7. 1500 w. Examples representing efficiency.

BUREAU of Mines during 1918, Work of the. Van H. Manning, *Coal Age* (Jan., 1919) **15**, 105–7. 2000 w. Coal mining and fuel investigation.

CEMENT-GUN in a bituminous coal mine, Use of the. M. S. Sloman, *Mine & Quarry* (Nov., 1918) **11**, 1092–5. 1700 w.

CEMENT-GUN process, Method and cost of coating mine roofs and ribs by. *Engng. & Contr.* (Jan. 15, 1919) **51**, 64–5. 1000 w.

CENTRAL and South America. *Engng. & Min. Jnl.* (Jan. 11, 1919) **107**, 113–7. 5000 w. Review of mining.

CENTRAL station power for mines. A. Tancig. *Bull.* Affiliated Engng. Socs. of Minn. (Dec., 1918) **3**, 206–7. 1200 w.

CHROME mining in Canada. Robert Harvil, *Engng. & Min. Jnl.* (Jan. 18, 1919) **107**, 144. 1000 w.

COAL-handling plant at Sewalls Point, Virginia. *Power* (Jan. 14, 1919) **49**, 54–6. 1500 w.

COAL hoist installations, New electric. *Coal Ind.* (Jan., 1919) **2**, 15–7. 2000 w.

COAL mines, Organization of production committees at bituminous. *Monthly Labor Rev.* (Nov., 1918) **7**, 36–8. 800 w.

COAL mining industry, Nova Scotia, Problems of. F. W. Gray, *Canad. Min. Jnl.* (Jan. 8, 1919) **40**, 4–5. 1200 w.

COAL mining in Natal during 1917. J. E. Vaughan, *South Afr. Engng.* (Nov., 1918) **29**, 163. 1000 w. Review.

COAL mining in the Orange Free State during 1917. G. E. B. Frood, *South Afr. Engng.* (Nov., 1918) **29**, 165. 1000 w. Review.

COAL-mining results in the United States in 1918 and the present outlook. *Coal Age* (Jan. 16, 1919) **15**, 81. 800 w.

COAL mining, Science and research in. George W. Harris, *Coal Age* (Jan. 2, 1919) **15**, 17-4 3000 w.

COAL stripping in the United States. Wilbur Greely Burroughs, *Coal Ind.* (Jan., 1919) **2**, 1–5. 3000 w. Serial.

COAL stripping operation, Modern. H. L Palmer, *Coal Ind.* (Jan., 1919) **2**, 6–8. 1800 w. Describes J. R. Crowe Co.'s plant at Scammon, Kan.

COAL tipple, An American. R. G. Read, *Coll. Guard.* (Dec. 27, 1918) **116**, 1352-3. 700 w. At Galloway, W. Va.

COAL tipple of the Granville mines. *Coal Ind.* (Jan., 1919) **2**, 13–4. 1000 w.

COLLIERIES, Reinforced concrete in. *Coll. Guard.* (Dec. 27, 1918) **116**, 1350–1. 1200 w. From paper by B. Taylor at meeting of Manchester Assn. of Engrs.

COLLIERY electrical undertakings. *Iron & Coal Tr. Rev.* (Dec. 27, 1918) **97**, 726. 2000 w. On Electric Power Supply Committee's report.

COLLIERY steam plant: the setting of Lancashire boilers. Edward Ingham, *Coll. Guard* (Jan. 3, 1919) **117**, 25. 1500 w.

CUTTING coal, etc. Mavor, Coulson & Moore, British Pat. 119954. *Ill. Off. Jnl.* (Dec 18, 1918) 2939. 100 w.

DREDGING areas, Topography and geology of. Charles Janin, *Min. & Sci. Pr.* III. (Jan 25, 1919) **118**, 122–3. 900 w.

ELECTRIC lamp for mines. French Pat. 488140, *Bull.* Off. Prop. Indust. (June 20, 1918) **38**, 88.

ELECTRICITY in mining. L. Fokes, *Sci. & Art of Min.* (Dec. 28, 1918) **29**, 169. 1200 w. Direct current motors; limitation of armature current.

EMPLOYMENT management at coal mines. A. W. Calloway, *Coal Ind.* (Jan., 1919) **2**, 20–1. 1500 w.

EXPLOSIONS in Prussian anthracite mines, remarkable during 1917. Mittellungen über einige der bemerkenswertesten Explosionen beim preussuschen Steinkohlenbergbau in Jahre, 1917, *Ztsch. Berg. Hütten u. Salinenwesen*. (July 23, 1918) **28**, 149–87. 38 p.

FIRES, Control of mine. M. Cabane, L'embouage des feux de mine, *Bull.* Compt. Rend. Mens. Soc. de Indust. Min. (3d No. 1918) **14**, 67–77. 10 p.

GOLD deposition in the Bendigo goldfield. *Queensland Govt. Min. Jnl.* (Dec., 1918) **19**, 593–4. 1200 w. From report of Commonwealth Advisory Council of Science and Industry.


Turning to the Tasks of Peace
For twenty-one months the Hercules Powder Co. has had but one thought, and aim—to contribute its uttermost for the winning of the war. Great plants have been built, new methods devised, sources of supply discovered that were before un-known.
Due to this development, made necessary by war, the company is today capable of serving the industries of peace to a greater extent than ever before.
The great industrial era which the country faces insures the certainty of there being ample opportunity for rendering this service. The use of explosives is essential to the great basic industrial enterprises. In mine and quarry, on the highway and along the railroad line, when the course of a river is changed or a dam built, where irrigation or drainage is necessary, and where idle lands are converted into fertile fields—there Hercules Powders will meet the demands of peace as they have met the demands of war.
HERCULES POWDER CO.
Chicago Hazleton, Pa. Pittsburgh, Pa.
Denver Chattanooga Pittsburg, Kan.
Joplin New York Salt Lake City
St. Louis San Francisco Wilmington, Del.
HERCULES EXTRA L.F.
40% STRENGTH
HERCULES POWDER CO.
HERCULES POWDER CO.

GOLD dredging installations in isolated districts, Power plants for. *Engng. & Contr.* (Jan. 15, 1919) **51**, 62–3. 1500 w.

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(See also Ore-dressing and Preparation of Coal, Coal and Coke, Metallurgy of Non-ferrous Metals)

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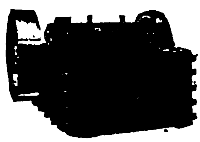

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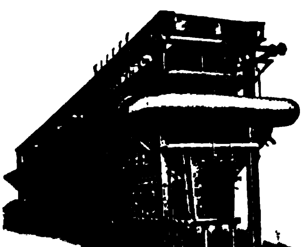

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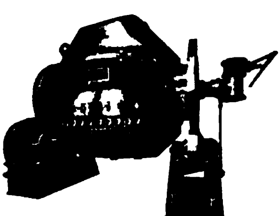

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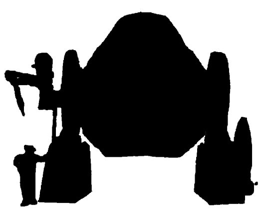

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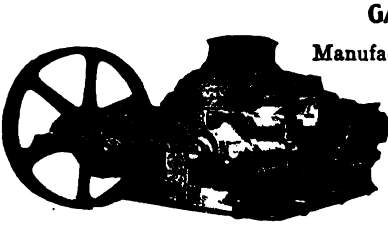

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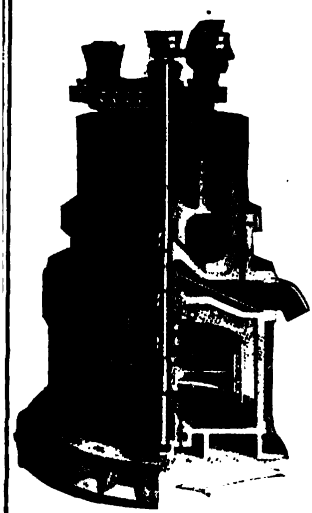

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Chute Plates & Launder Liners
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Chutes
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Classifiers
Allis-Chalmers Mfg. Co., Milwaukee. Wis.
Chalmers & Williams, Inc., Chicago Heights, Ill.
Colorado Iron Works Co., Denver, Colo
Deister Concentrator Co., Fort Wayne, Ind.
Dorr Co., Denver, Colo.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Coal and Ash Handling Machinery
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Coal Mining Machines
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Coal Mining Plants
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Coal Storage and Rehandling Machinery
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Coatings, Roof
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Collectors, Dust
Macleod Co., Bogen St., Cincinnati, Ohio.

Compass, Maas Patent Drill Hole
Derby, Jr., E. L., Agent, Ishpeming, Mich.

Compressors, Air
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Concentrators
Colorado Iron Works Co., Denver, Colo.
Deister Concentrator Co., Fort Wayne, Ind.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Condensers, Surface
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Contractors, Diamond Drilling
Longyear Co., E. J., 710 Security Bldg., Minneapolis, Minn.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Converters, Copper
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Converters, Electric, Rotary
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Conveyors, Belt
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Robins Conveying Belt Co., Park Row Bldg., New York City.

Conveyors, Cable Flight
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Conveyors, Chain Flight
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Conveyors, Pan or Apron
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Conveyors, Screw
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Core Drilling
Longyear Co., E. J., 710 Security Bldg., Minneapolis, Minn.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Coverings, Pipe and Boiler
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Crucibles
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.
Mine and Smelter Supply Co., 42 Broadway, New York City.

Crushers, Coal and Coke
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Robins Conveying Belt Co., Park Row Bldg., New York City.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Crushers, Disc
Chalmers & Williams, Inc., 1465 Arnold St., Chicago Heights, Ill.

Crushers, Jaw
Chalmers & Williams, Inc., 1465 Arnold St., Chicago Heights, Ill.

Crushers, Ore
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Buchanan Co., C. G., 90 West St., New York City.
Chalmers & Williams, Inc., 1465 Arnold St., Chicago Heights, Ill.
Colorado Iron Works Co., Denver, Colo.
Fuller-Lehigh Co., Fullerton, Pa.
Heil Chemical Co., Henry, 210–214 S. 4th St. St. Louis, Mo.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Boradway, New York City.

Crushing and Grinding Machinery
Chalmers & Williams, Inc., 1465 Arnold St., Chicago Heights, Ill.

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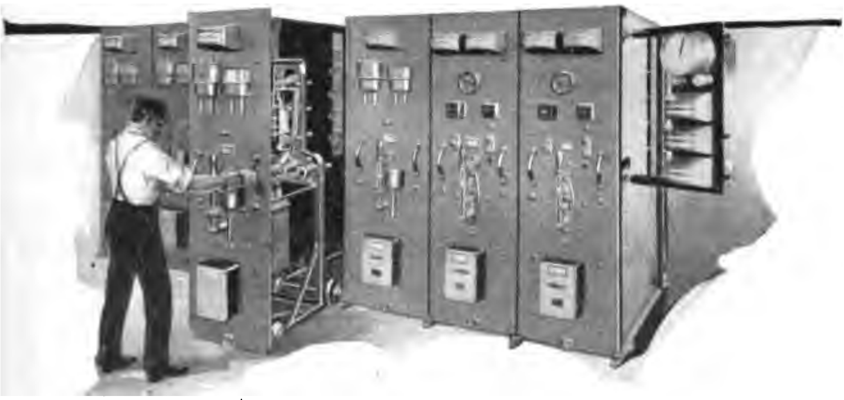

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*Southwest General Electric Company. For CANADIAN BUSINESS refer to Canadian General Electric Company, Ltd., Toronto, Ont.
GENERAL FOREIGN SALES OFFICES: Schenectady, N. Y.; 120 Broadway, New York City; 83 Cannon St., London, E. C., England

CLASSIFIED LIST OF MINING AND METALLURGICAL EQUIPMENT

Crushing Roll Parts
American Manganese Steel Co., McCormick Bldg., Chicago Ill.
Chalmers & Williams, Inc., Chicago Heights, Ill.

Crushing Rolls (See Rolls, Crushing)
Chalmers & Williams, Inc., Chicago Heights, Ill.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Cupro-Magnesium Metal
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Cupro-Vanadium
Primos Chemical Co., Primos, Pa.

Cyanide
Roessler & Hasslacher Chemical Co., 100 William St., New York City.

Cyaniding Equipment
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Chalmers & Williams, Inc., Chicago Heights, Ill.
Colorado Iron Works Co., Denver, Colo.
Dorr Co., Denver, Colo.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Dead Burned Magnesite
Harbison-Walker Refractories Co., Farmers' Bank Bldg., Pittsburgh, Pa.

Dewaterers
Colorado Iron Works Co., Denver, Colo.
Dorr Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Diamond Drilling
Longyear Co., E. J., 710 Security Bldg., Minneapolis, Minn.

Dredging Machinery
Flory Mfg. Co., S., Bangor, Pa.

Drill Hole Compass (See Compass, Drill Hole)

Drills, Core
Longyear Co., E. J., 710 Security Bldg., Minneapolis, Minn.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Drills, Diamond
Longyear Co., E. J., 710 Security Bldg., Minneapolis, Minn.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Drills, Electric
Denver Rock Drill Mfg. Co., Denver, Colo.
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Drills, Hammer
Denver Rock Drill Mfg. Co., Denver, Colo.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Drills, Prospecting
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Drills, Rock
Denver Rock Drill Mfg. Co., Denver, Colo.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Dryers, Coal
Ruggles-Coles Engineering Co., 50 Church St., New York City.

Dryers, Ore
Ruggles-Coles Engineering Co., 50 Church St., New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Wedge Mechanical Furnace Co., Greenwich Point, Philadelphia, Pa.

Dryers, Rotary
Fuller-Lehigh Co., Fullerton, Pa.
Ruggles-Coles Engineering Co., 50 Church St., New York City.

Dryers, Sand and Gravel
Macleod Co., Bogen St., Cincinnati, Ohio.
Ruggles-Coles Engineering Co., 50 Church St., New York City.

Dumps, Rotary
Wood Equipment Co., McCormick Bldg., Chicago, Ill.

Dynamite
Du Pont de Nemours & Co., E. I., Wilmington, Del.
Hercules Powder Co., Wilmington, Del.

Dynamos (See Generators, Electric)

Electrical Machinery
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Elevators, Bucket
Buchanan Co., C. G., 90 West St., New York City.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Robins Conveying Belt Co., Park Row Bldg., New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Emery Ore
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

End Loaders (See Loaders, End)

Engines, Gas and Gasoline
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Engines, Haulage
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.

Engines, Hoisting
Flory Mfg. Co., S., Bangor, Pa.
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Engines, Oil
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Engines, Steam
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Explosives
Du Pont de Nemours & Co., E. I., Wilmington, Del.
Hercules Powder Co., Wilmington, Del.

Fans, Ventilating
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Feeders, Ore
Buchanan Co., C. G., 90 West St., New York City.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Robins Conveying Belt Co., Park Row Bldg., New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Ferro-Chrome
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Ferro-Manganese
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Ferro-Molybdenum
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.
Primos Chemical Co., Primos, Pa.

CLASSIFIED LIST OF MINING AND METALLURGICAL EQUIPMENT

Ferro-Silicon
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Ferro-Tungsten
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.
Primos Chemical Co., Primos, Pa.

Ferro-Vanadium
Primos Chemical Co., Primos, Pa.

Filtering Paper
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Filters
Chalmers & Williams, Inc., Chicago Heights, Ill.
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Fire Clay
Harbison-Walker Refractories Co., Farmers' Bank Bldg., Pittsburgh, Pa.
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Flotation, Oil
Colorado Iron Works Co., Denver, Colo.

Flue Welding Machines
Macleod Co., Bogen St., Cincinnati, Ohio.

Fluorescent Calcium Tungstate
Primos Chemical Co., Primos, Pa.

Fluorspar (Domestic and Foreign)
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Forges, Oil and Rivet
Macleod Co., Bogen St., Cincinnati, Ohio.

Forgings, Heavy
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.

Fuller Mill Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Furnaces, Assay
Heil Chemical Co., Henry, 210–214 S.4th. St., St. Louis, Mo.
Macleod Co., Bogen St., Cincinnati, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.

Furnaces, Electric
General Electric Co., Schenectady, N. Y.
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Furnaces, Flue Welding
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Gas
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Lead
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Mechanical Roasting
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Wedge Mechanical Furnace Co., Greenwich Point, Philadelphia, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Furnaces, Muffle
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Oil
Macleod Co., Bogen St., Cincinnati, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.

Furnaces, Reverberatory
Macleod Co., Bogen St., Cincinnati, Ohio.

Furnaces, Smelting
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Furnaces, Tire Heating
Macleod Co., Bogen St., Cincinnati, Ohio.

Gears
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Generators, Acetylene Welding and Cutting
Macleod Co., Bogen St., Cincinnati, Ohio.

Generators, Electric
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Grinders, Sample
Chalmers & Williams, Inc., Chicago Heights, Ill.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.

Grizzly & Riffle Bars (For Hydraulic Mines)
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Guns, Cement
Macleod Co., Bogen St., Cincinnati, Ohio.

Guns, Concrete
Macleod Co., Bogen St., Cincinnati, Ohio.

Gyratory Crusher Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.
Chalmers & Williams, Inc., Chicago Heights, Ill.

Hangers, Mine
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Hitchings Mine Car
Macomber & Whyte Rope Co., Kenosha, Wis.

Hoists, Electric
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Flory Mfg. Co., S., Bangor, Pa.
General Electric Co., Schenectady, N. Y.
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Hoists, Skip
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Hoists, Steam
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Flory Mfg. Co., S., Bangor, Pa.
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.
Mine and Smelter Supply Co., 42 Broadway, New York City.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Hoppers, Weigh
Holmes & Bros., Inc., Robt., 30 N. Hazel St., Danville, Ill.

Hose, Air
Denver Rock Drill Mfg. Co., Denver, Colo.
Goodrich Rubber Co., B. F., Akron, O.

Hydrated Ferric Oxide (For Gas Purification)
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Hydraulic Mining Machinery
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Insulators, Third Rail
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Jackets, Water
Traylor Engineering & Mfg. Co., Allentown, Pa.

Jaw Crusher Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.
Chalmers & Williams, Inc., Chicago Heights, Ill.

CLASSIFIED LIST OF MINING AND METALLURGICAL EQUIPMENT

Jigs
- Allis-Chalmers Mfg. Co., Milwaukee, Wis.
- Colorado Iron Works Co., Denver, Colo.
- Chalmers & Williams, Inc., Chicago Heights, Ill.
- Mine and Smelter Supply Co., 42 Broadway, New York City.
- Traylor Engineering & Mfg. Co., Allentown, Pa.
- Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Laboratory Supplies
- Heil Chemical Co., Henry, 210-214 S. 4th St., St. Louis, Mo.

Lamps, Acetylene
- Macleod Co., Bogen St., Cincinnati, Ohio.

Lamps, Electric
- General Electric Co., Schenectady, N. Y.
- Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Lead Acetate
- Heil Chemical Co., Henry, 210-214 S. 4th St., St. Louis, Mo.

Linings, Ball and Tube
- Chalmers & Williams, Inc., Chicago Heights, Ill.
- Traylor Engineering & Mfg. Co., Allentown, Pa.

Linings, Brake
- Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Litharge
- Heil Chemical Co., Henry, 210-214 S. 4th St., St. Louis, Mo.

Loaders, End
- Holmes & Bros., Inc., Robt., 30 N. Hasel St., Danville, Ill.

Loading Booms
- Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio

Locomotives, Compressed Air
- General Electric Co., Schenectady, N. Y.
- Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Locomotives, Electric Trolley
- General Electric Co., Schenectady, N. Y.
- Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
- Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Locomotives, Gasoline
- Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Locomotives, Steam
- Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

Locomotives, Storage Battery
- General Electric Co., Schenectady, N. Y.
- Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
- Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Low Carbon Ferro-Manganese
- Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnesia Brick
- Harbison-Walker Refractories Co., Farmers' Bank Bldg., Pittsburgh, Pa.
- Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnesite Cement
- Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnesium Metal (Ingots and Powder.)
- Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Magnetic Pulleys (See Pulleys, Magnetic)

Manganese Dioxide (Lump and Ground)
- Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Manganese Ore
- Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Meters, Electric
- General Electric Co., Schenectady, N. Y.
- Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Mica
- Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Mills, Ball, Tube and Pebble
- Allis-Chalmers Mfg. Co., Milwaukee. Wis.
- Chalmers & Williams, Inc., 1465 Arnold St., Chicago Heights, Ill.
- Colorado Iron Works Co., Denver, Colo.
- Fuller-Lehigh Co., Fullerton, Pa.
- Hardinge Conical Mill Co., 120 Broadway, New York City.
- Mine and Smelter Supply Co., 42 Broadway, New York City.
- Traylor Engineering & Mfg. Co., Allentown, Pa.
- Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Mills, Chilean
- Allis-Chalmers Mfg. Co.. Milwaukee, Wis.
- Chalmers & Williams, Inc., Chicago Heights, Ill.
- Colorado Iron Works Co., Denver, Colo.
- Traylor Engineering & Mfg. Co., Allentown, Pa.

Mills, Stamp
- Allis-Chalmers Mfg. Co., Milwaukee, Wis.
- Chalmers & Williams, Inc., Chicago Heights, Ill.
- Colorado Iron Works Co., Denver, Colo.
- Traylor Engineering & Mfg. Co., Allentown, Pa.
- Worthington Pump & Machinery Corp'n. 115 Broadway, New York City.

Mine Car Hitchings (See Hitchings, Mine Car)

Mining Machinery
- Chalmers & Williams, Inc., 1465 Arnold St., Chicago Heights, Ill.

Molybdate of Ammonia
- Primos Chemical Co., Primos, Pa.

Molybdate of Calcium
- Primos Chemical Co., Primos, Pa.

Molybdate of Soda
- Primos Chemical Co., Primos, Pa.

Molybdenum Metal
- Primos Chemical Co., Primos, Pa.

Molybdenum Ore, Buyers of
- Primos Chemical Co., Primos, Pa.

Molybdic Acid
- Primos Chemical Co., Primos, Pa.

Motors, Electric
- Allis-Chalmers Mfg. Co., Milwaukee, Wis.
- General Electric Co., Schenectady, N. Y.
- Mine and Smelter Supply Co., 42 Broadway, New York City.
- Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Muffles
- Mine and Smelter Supply Co., 42 Broadway, New York City.

Ore-Bedding Systems
- Robins Conveying Belt Co., Park Row Bldg., New York City.

Ore Handling Machinery
- Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.
- Robins Conveying Belt Co., Park Row Bldg., New York City.

Ore Milling Machinery
- Chalmers & Williams, Inc., Chicago Heights, Ill.
- Colorado Iron Works Co., Denver, Colo.
- Mine and Smelter Supply Co., 42 Broadway, New York City.
- Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Ores, Buyers and Sellers of
- Vogelstein & Co., Inc., L., 42 Broadway, New York City.

Oxy-Acetylene Apparatus
- Macleod Co., Bogen St., Cincinnati, Ohio.

CLASSIFIED LIST OF MINING AND METALLURGICAL EQUIPMENT

Screens, Shaking
Chalmers & Williams, Inc., 1465 Arnold St., Chicago Heights, Ill.
Holmes & Bros., Inc., Robt., 30 N. Hasel St., Danville, Ill.

Separators, Magnetic
Buchanan Co., C. G., 90 West St., New York City.

Shaft Sinking and Development Work
Longyear Co., E. J., 710 Security Bldg., Minneapolis, Minn.

Sharpeners, Drill
Denver Rock Drill Mfg. Co., Denver, Colo.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Silica Brick
Harbison-Walker Refractories Co., Farmers' Bank Bldg., Pittsburgh, Pa.

Skip Hoists (See Hoists, Skip)
Macomber & Whyte Rope Co., Kenosha, Wis.
Roebling's Sons Co., John A., Trenton, N. J.

Smelters
Vogelstein & Co., Inc., L., 42 Broadway, New York City.

Smelting Machinery
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Colorado Iron Works Co., Denver, Colo.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

Soda Ash
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Spelter
Illinois Zinc Co., Peru, Ill.

Spiegeleisen
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Sprockets
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Stamp Mill Parts
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.
Chalmers & Williams, Inc., Chicago Heights, Ill.

Steel, Drill, Hollow and Solid
Denver Rock Drill Mfg. Co., Denver, Colo.
International High Speed Steel Co., 99 Nassau St., New York, N. Y.
Sullivan Machinery Co., 122 So. Michigan Ave., Chicago, Ill.

Steel, Tool
International High Speed Steel Co., 99 Nassau St., New York, N. Y.

Stokers
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Switchboards
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Tables, Concentrating (See Concentrators)

Test Lead
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Thawers, Switch
Macleod Co., Bogen St., Cincinnati, Ohio.

Thermometers
Heil Chemical Co., Henry, 210–214 S. 4th St., St. Louis, Mo.

Thickeners, Slime
Colorado Iron Works Co., Denver, Colo.
Dorr Co., Denver, Colo.

Tipple Machinery Equipment
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Torches, Cutting and Welding
Macleod Co., Bogen St., Cincinnati, Ohio.

Towers and Bridges, Stocking and Reclaiming
Robins Conveying Belt Co., Park Row Bldg., New York City.

Tramways, Wire Rope, Aerial
Leschen & Sons Rope Co., A., 920 N. 1st St., St. Louis, Mo.
Macomber & Whyte Rope Co., Kenosha, Wis.
Roebling's Sons Co., John A., Trenton, N. J.

Transformers, Electric
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Traps, Steam
Johns-Manville Co., H. W., 296 Madison Ave., New York City.

Tungstate of Ammonia
Primos Chemical Co., Primos, Pa.

Tungstate of Soda
Primos Chemical Co., Primos, Pa.

Tungsten Metal
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.
Primos Chemical Co., Primos, Pa.

Tungsten Ore
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.

Tungsten Ore, Buyers of
Primos Chemical Co., Primos, Pa.

Tungstic Acid
Lavino and Co., E. J., Bullitt Bldg., Philadelphia, Pa.
Primos Chemical Co., Primos, Pa.

Turbines, Hydraulic
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Turbines, Steam
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Valves, Pump
Goodrich Rubber Co., B. F., Akron, O.

Vanadate of Ammonia
Primos Chemical Co., Primos, Pa.

Vanadic Acid
Primos Chemical Co., Primos, Pa.

Vanadium Chloride
Primos Chemical Co., Primos, Pa.

Vanadium Ore, Buyers of
Primos Chemical Co., Primos, Pa.

Ventilating Fans (See Fans, Ventilating)

Wagon Loaders
Jeffrey Mfg. Co., 902 N. 4th St., Columbus, Ohio.

Weigh Hoppers (See Hoppers, Weigh)

Wheels
American Manganese Steel Co., McCormick Bldg., Chicago, Ill.

Wheels, Mine Car
Fuller-Lehigh Co., Fullerton, Pa.

Wire, Iron, Steel and Copper
Roebling's Sons Co., John A., Trenton, N. J.

Wire Mechanism (Lever Control)
Gwilliam Co., 253 W. 58th St., New York City.

Wire Rope (See Rope, Wire)

Wires and Cables, Electrical
General Electric Co., Schenectady, N. Y.
Goodrich Rubber Co., B. F., Akron, O.
Roebling's Sons Co., John A., Trenton, N. J.

Zinc Dust
Vogelstein & Co., Inc., L., 42 Broadway New York City.

Zinc Sheet
Illinois Zinc Co., Peru, Ill.

ALPHABETICAL LIST OF ADVERTISERS

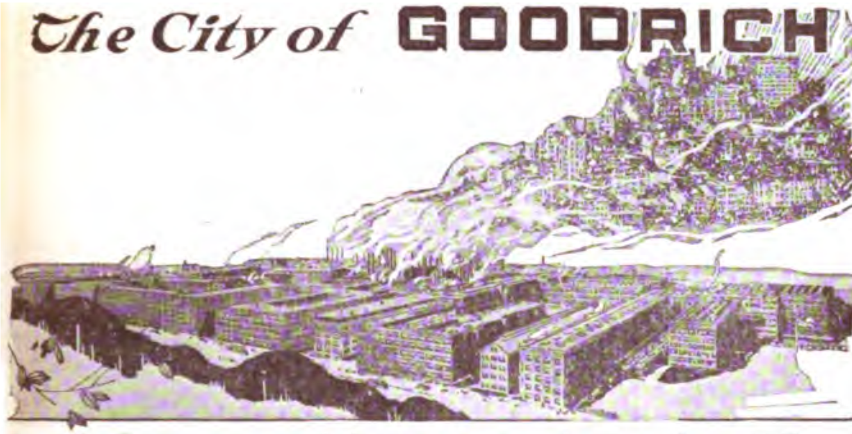
(With Summary of Products)

See pages 30-39 for Classified List of Mining and Metallurgical Equipment

* Advertisement does not appear in this issue, but products are listed in Classified List of Mining and Metallurgical Equipment.

ALPHABETICAL LIST OF ADVERTISERS (Continued)

* Advertisement does not appear in this issue, but products are listed in Classified List of Mining and Metallurgical Equipment.



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SUPPOSE that every man, woman and child in Sharon, Pa., for example, suddenly stopped their everyday occupations and started making rubber goods—and you will get a faint idea of the stupendous magnitude of the great Goodrich Rubber Factories.

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Our experts are at your service. They will study your individual mechanical needs as conscientiously as if the business were their own. Take advantage of this service.

THE B.F. GOODRICH RUBBER COMPANY
The City of Goodrich—Akron, Ohio

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"LONGLIFE"
Conveyor Belts

"MARATHON"
High Speed Belts

"COMMANDER"
Pneumatic Hose, Steam, Suction, Water, Mill, Boiler Washout, Oil, Acid and Chemical Hose

"WHITE KING"
Fire Hose

Gaskets, Tubing and Mechanical Rubber Goods of all kinds

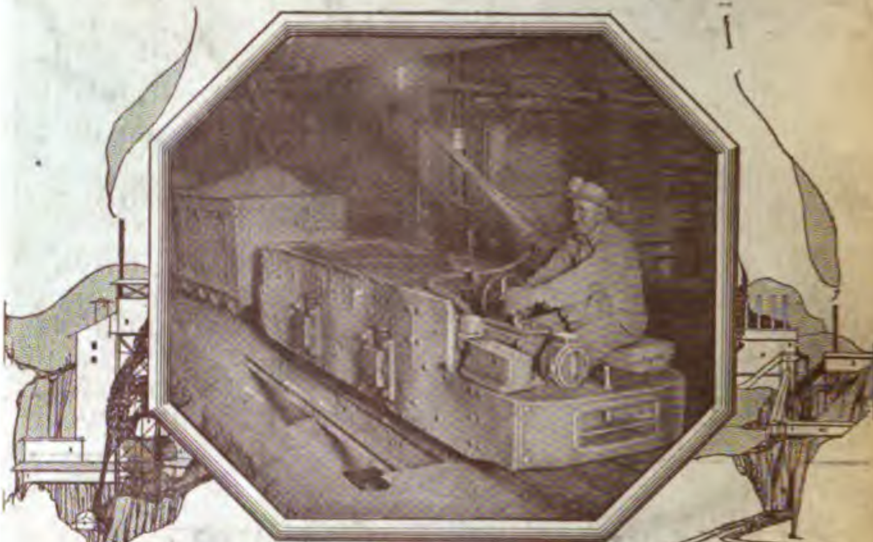
Wires and Cables

Boots and Shoes

Tires for automobiles, bicycles, motor trucks and airplanes.

GOODRICH

MECHANICAL RUBBER GOODS



Haulage Locomotive at Montana Mining Company
Hurley, Wis.

No. 148 April 1919

Bulletin of the American Institute of Mining and Metallurgical Engineers

with which is consolidated the

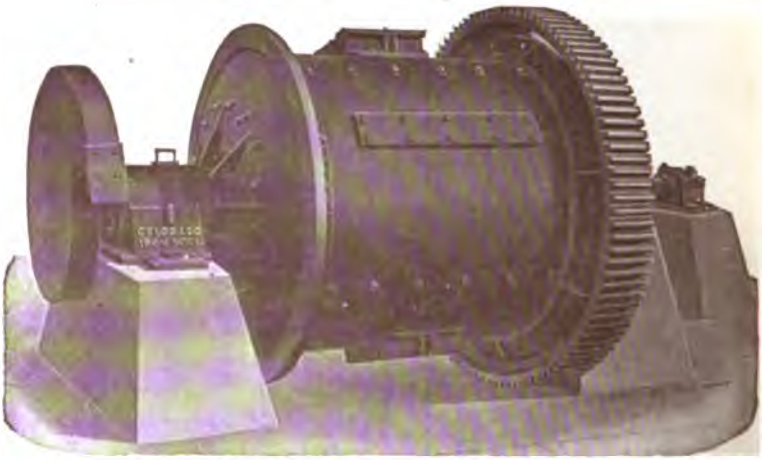
American Institute of Metals

SPECIAL FEATURES

PUBLISHED MONTHLY

This Convertible Discharge Ball Mill

Is a Distinctly Advantageous Buy



Discharge through a grating or directly through the trunnion may eventually prove best for your particular conditions. Which it will be can rarely be positively foreseen. Why, therefore, tie your hands with a ball mill, inflexible in this respect, when

The Colorado Convertible Discharge Ball Mill

if installed, may readily be changed from one system of discharge to the other?

In addition to this advantage, our ball mills are of massive, thorough construction and embody the results of an extensive experience in ball mill building.

Send for Pamphlet 31

Colorado Iron Works Co.

Ore Milling Machinery and Smelting Equipment Since 1860

30 Church Street
NEW YORK CITY

Denver, Colo.

Bulletin of the American Institute of Mining and Metallurgical Engineers

WITH WHICH IS CONSOLIDATED THE

American Institute of Metals

No. 148 APRIL 1919

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TECHNICAL PAPERS

ADVERTISING

BULLETIN OF THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

WITH WHICH IS CONSOLIDATED THE

AMERICAN INSTITUTE OF METALS

No. 148 APRIL 1919

Published Monthly by the American Institute of Mining Engineers at 212–218 York St., York, Pa., H. A. Wisotzkey, Publication Manager. Editorial Office, 29 West 39th St., New York, N. Y., Bradley Stoughton, Editor. Cable address, "Aime," Western Union Telegraph Code. Subscription (including postage), $10 per annum; to members of the Institute, public libraries, educational institutions and technical societies, $5 per annum. Single copies (including postage), $1 each; to members of the Institute, public libraries, etc., 50 cents each.

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EFFICIENCY IN DEVELOPMENT OF NATURAL RESOURCES

With the signing of the armistice on Nov. 11, the direction of the main concentration of effort of the United States was changed. In order to win the war, all industrial efforts had to be organized and centralized. With the war won and peace in sight, this centralization of effort stopped and the full play of individual initiative was allowed to resume its sway in the community. During this period of reversal of direction of effort, there was a natural loss of momentum and the United States, as well as the rest of the world, is in for a period of readjustment.

The immense progress that was made in one direction under the stress of the necessities of war, which focused the energies of a nation in one direction, is an outstanding example of what can be accomplished if a community with many varying interests can be united on one objective which it desires to attain. The realization that the fusing of many interests into one stream of effort is difficult should not prevent us from taking the long view ahead that is necessary in order to be able to measure the progress made. If we don't have a mountain peak to guide us, we are very likely to run in circles in the plain without reaching the goal to which we strive.

The most efficient development of natural resources is an ideal that, from a material point of view, appeals to the engineer. This ideal includes giving of opportunities to everyone to take a share in the development of these resources. It also contemplates rewarding foresight

and energy by giving a chance to the man-who-can, to acquire and develop as much property as his energy and resources will permit. It proposes to reward thrift, capacity, and knowledge and, by comparison, to punish the lack of these characteristics. Some too great worshippers of efficiency have been lead into undesirable results. The world now knows that the development of any natural resource which demands that the workers shall receive inadequate wages and have less leisure than they are entitled to is not worth doing.

The most efficient development of natural resources connotes the thrifty use of labor. Our nation has received a tremendous impetus in the cause of thrift, as applied to money, during the four campaigns for the flotation of the Liberty Loans; but due to the necessities of speed and volume of output in order to win the war, it has unlearned the lesson of thrift in the use of labor. Owing to the rapid demobilization of the army and the natural disposition to take stock throughout industries of peace, there is, in many quarters, a temporary abundance of labor. Past experience of the productive demands of America and a close sizing up of the present industrial situation lead me to believe that when industry again acquires momentum there will be a shortage of labor. This will be accentuated as soon as ocean travel is freer. It is estimated by passenger agents that about 1,000,000 foreigners will return to their own country as soon as they can do so with reasonable ease. Undoubtedly many inhabitants of Europe will desire to come to America to share the high wages obtaining here and to escape the high taxation that will obtain there; the European Governments will probably make it as difficult as possible for their inhabitants to emigrate. The United States will not be the only place that will offer attractions to the would-be emigrant from Europe; Canada, Australia, and the South American countries will all offer inducements and will advertise those inducements.

The resultant of all these forces seems to me to be in the direction of a shortage of labor. If this estimate of the situation is correct, it behooves us to re-learn the lesson of the thrifty use of labor as speedily as possible. The most thrifty use of labor is achieved by seeing that each individual laborer is suited to the job by which he earns a living.

SIDNEY J. JENNINGS.

CLOSING DATE FOR MANUSCRIPTS, JUNE 1, 1919

The Committee on Papers and Publications has set June 1, 1919, as the closing date for the receipt of manuscripts intended for the Chicago meeting, which is to be held in September, 1919. Manuscripts must be received by the Secretary on or before this date. If they are sent through members of the technical committees they must be sent to those committees long enough in advance to be forwarded and in the hands of the Secretary by the time specified.

YEAR BOOK FOR 1919

The Year Book of the Institute will be mailed with the May *Bulletin*. Its membership lists, both alphabetic and geographic, are corrected to Mar. 1, and the lists of officers and committees are correct to date.

W. R. INGALLS RETIRES FROM ENGINEERING AND MINING JOURNAL

W. R. Ingalls, since 1905 editor of the *Engineering and Mining Journal*, retires from that position with the issue of Mar. 22, to open offices in New York City as a consulting engineer. The severing of this connection will not be complete, however, as Mr. Ingalls will continue as consulting editor, and will handle the metal-market quotations in the *Journal* which are now the accepted authority for the government settlements of ore importations and the basis of practically all the ore settlements between miners and smelters throughout the country.

No greater compliment can be paid to Mr. Ingalls than this, unless it is the recognized fact that these quotations have been made what they are by his ability and his integrity, which secured for him channels of information vital to the accurate estimating of the market, but denied to anyone else. The *Journal*, under the strong hand of Mr. Ingalls, has always been the acme of ethics in technical journalism, and the best wish that can be given to his successor, not yet announced, is that the *Journal* may long continue to live up to the standards not originated, but so consistently maintained and strengthened by Mr. Ingalls. His spelter statistics are accepted as authoritative wherever the English language is read and zinc ore is mined.

He has found time during his very arduous years on the *Journal* to be the author of several works on the resources and metallurgy of zinc, lead, cadmium, etc.; for 5 years was the editor of *Mineral Industry;* and was consulting engineer for the Bureau of Mines and joint author of their voluminous and authoritative work on mine safety rules. His retirement from the *Journal* is a distinct loss to every one of the *Journal's* readers individually and to the profession as a whole. Universal good wishes go with Mr. Ingalls to his new field, which has for a long time been offering him professional attractions that his confining editorial work has not permitted him to accept.

PHILIP N. MOORE ON WAR MINERAL RELIEF COMMISSION

Past-president Philip N. Moore has accepted the position of engineer member of the War Mineral Relief Commission and has already taken up the work. J. E. Spurr is the chief engineer of the Commission and is now organizing the examining staff.

MEETING OF BOARD OF DIRECTORS

At the meeting of the Board of Directors held Tuesday, Feb. 18, 1919, there were present nineteen Directors and the Secretary of the Institute.

The following officers were elected for the year: A. R. Ledoux, first vice-president; George D. Barron, treasurer; Bradley Stoughton, secretary; and the following committees: Executive Committee, Finance Committee, Library Committee, Committee on Papers and Publications, Committe on Membership. The personnel of these committees will be published in the Year Book.

A vote of thanks was passed to each officer and member of the several committees that arranged the New York Meeting of the Institute. The meeting dates for the Board were arranged for the year. The report of the Treasurer was presented, also the report of the Auditing

Committee; they were accepted and filed. The annual budget was adopted.

There were elected twenty-eight members, nine associates, and twenty-one junior associates. The status of one member was changed from junior associate to member. One member was reinstated. The resignations of five members were accepted. Dues were suspended of four members on active duty with the Allied Armies.

A report was presented from the Institute's representatives on the Naval Consulting Board and a report from the Institute's representative on the Engineering Delegation to France. There were also presented the annual reports of the United Engineering Society and the Engineering Societies' Library. The Committee on Development of Institute Activities presented a preliminary report.

LOCAL SECTION NEWS

MONTANA SECTION

FREDERICK LAIST, *Chairman* F. W. BACORN, *Vice-chairman*
E. B. YOUNG, *Secretary-Treasurer*, 526 Hennesy Building, Butte, Mont.
C. H. CLAPP C. D. DEMOND

The Montana Section held its annual meeting at the Silver Bow Club, Butte, Mont., on Friday, Feb. 7. The technical session was preceded by a dinner at which 54 members and guests were seated. N. B. Braly presided at the dinner and the business and technical sessions. The officers whose names are noted above were elected for the ensuing year.

H. B. Pulsifer presented a paper on The Metallurgy of Aluminum and Magnesium; it was discussed by C. H. Clapp and F. A. Linforth. J. C. Horgan presented a paper on The Manufacture of High Explosives and their Use in Metal Mines; it was discussed by C. W. Morse, J. J. Carrigan, and C. W. Goodale.

The matter of reformed spelling as proposed in a circular letter coming from Palo Alto, Calif., was discussed, after which the Secretary was instructed to write to Secretary Stoughton and ask that when the matter is opened for discussion in New York he present the emphatic protest of the Montana Section against the alleged reforms in spelling.

E. B. YOUNG, *Secretary*.

ST. LOUIS SECTION

F. V. DESLOGE, *Chairman* P. B. BUTLER, *Vice-chairman*
F. F. JORGENSEN, *Vice-chairman* J. FRANK THOMPSON, *Vice-chairman*
W. E. MCCOURT, *Secretary-Treasurer*, Washington Univ., St. Louis, Mo.
R. W. BARRELL J. N. HOUSER
R. E. HOFFMAN EUGENE MCAULIFFE H. T. MANN

The sixth annual meeting of the Section was held at the St. Louis Club, on Mar. 1. The meeting was preceded by a dinner at which 63 members and guests were present. Among the guests were H. V. Winchell, President of the Institute; Bradley Stoughton, Secretary of the Institute; R. C. Allen, State Geologist of Michigan; and B. L. Brown. President of the Engineers Club of St. Louis. The officers named above were elected for the year 1919.

The following resolution was adopted.

WHEREAS, the activities of the several national engineering societies are at the present time becoming more and more strongly directed along lines of coöperation and coördination of effort in public affairs, and

WHEREAS, the Associated Engineering Societies of St. Louis offers an opportunity for the members of this Section to coöperate with the colleagues in the profession, now therefore, be it

RESOLVED: that the St. Louis Section of the American Institute of Mining and Metallurgical Engineers affiliate with the Associated Engineering Societies of St. Louis.

The Chairman then introduced President Winchell, who presented an eloquent appeal to the engineer and to the American Institute of Mining and Metallurgical Engineers for more specific and enlarged service during this trying period of reconstruction. The Secretary of the Institute, Bradley Stoughton, reported on the New York meeting and announced the definite change of the name of the Institute from the American Institute of Mining Engineers to the American Institute of Mining and Metallurgical Engineers. He also outlined the plans for the September meeting of the Institute to be held in Chicago, and spoke in general of the activities of the Institute. R. C. Allen måde an interesting address on the subject of the New Revenue Law and Mine Taxation. Philip N. Moore was the last of the speakers.

BOSTON SECTION

ALFRED C. LANE, *Chairman* GEORGE A. PACKARD, *Vice-chairman*
H. M. BOYLSTON, *Secretary-Treasurer*, 26 Abbot Bldg., Cambridge, Mass.
R. L. AGASSIZ FRED W. DENTON

The fiftieth meeting of the Boston Section was held at the Boston City Club on Monday, Feb. 3. A letter from the Duluth Engineers Club relating to the possibilities of closer organization and coöperation between the several American technical societies was read but no action was taken. Professor Lindgren, who was to be the speaker of the evening, was prevented by illness at the last moment from attending, so Prof. Lane entertained the society for about an hour with an extremely interesting series of lantern slides, portraying the geography of the war, including its physiographic features and the relation between the German war aims and the economic distribution of colonies and mineral deposits, and especially the iron ore, coal and oil.

Prof. T. Whittemore, who has been in Russia or the Balkans during a large part of the last 5 or 6 years in Red Cross and other work for children, gave an informal talk on present conditions in Russia and the opportunities for American and Allied aid. He brought out these points: (1) That there is a real Russian nation, although thoroughly impregnated with German influence; (2) that the real Russian has a self-centered childlike character and is, or was, intensely religious with a strong belief in miracles, these characteristics being fostered by the Imperial Russian Government and preventing any real sense of citizenship or consciousness of statehood among the people; (3) that there is hope of a revived Russian nation in some more democratic form than in the past, especially if outside aid can be obtained; (4) that Bolshevism is anarchy. Many questions were asked of the speaker to which he replied with clear and convincing answers.

The Chairman appointed the following nominating committee to bring in names for president, vice-president, and secretary-treasurer, to be voted on at the annual meeting on Mar. 3. A. H. Eustis, chairman, Prof. Albert Sauveur, Prof. E. E. Bugbee.

H. M. BOYLSTON, *Secretary-Treasurer.*

TULSA SECTION

ALF G. HEGGEM, *Chairman* ALEXANDER DEUSSEN, *Vice-chairman*
CHARLES H. TAYLOR, *Vice-chairman* ERASMUS HAWORTH, *Vice-chairman*
M. M. VALERIUS, *Junior Vice-chairman*
JAMES H. GARDNER, *Secretary-Treasurer*, Tulsa, Okla.
IRVING PERRINE J. J. RUTLEDGE S. H. WORRELL

At the last meeting of the Tulsa Section, Dr. J. J. Rutledge, of McAlester, Okla., was elected chairman for the next year and C. L. Severy, of Tulsa, was chosen secretary. We are now on our feet in good shape and hope to prove a useful branch of the Institute.

JAMES H. GARDNER, *Secretary-Treasurer.*

SAN FRANCISCO SECTION

F. W. BRADLEY, *Chairman* T. A. RICKARD, *Vice-chairman*
W. H. SHOCKLEY, *Secretary-Treasurer*, 959 Waverley St., Palo Alto, Calif.
D. M. RIORDAN C. F. TOLMAN, JR.

On Jan. 14, the meeting was at the Engineers' Club; twenty-nine were at the dinner and forty at the subsequent meeting. The counting of the ballots showed that the above officers were elected for the coming year. In the absence of Chairman Bradley, the former chairman, Mr. Elliott, presided. The report of the treasurer showed that $239.66 has been spent during the year; the principal items were notices to members $110; rent of rooms for meetings $93. A. K. P. Harmon, Jr. and Walter Stalder were appointed auditors.

Chairman Elliott gave the report of the committee appointed to act with the Joint Council of the Engineering Societies of San Francisco concerning the bill for licensing engineers that is now before the California legislature. T. A. Rickard was appointed a delegate to act with the committee in New York that has been appointed to consider the future development of the Institute.

R. E. Collom, of the California State Mining Bureau, read a paper on the "Comparison of results obtained by various methods of excluding water from oil wells in California." The paper is a summary of an article that will appear in Chapter II of the third annual report of the State Oil and Gas Supervisor, *Bulletin* No. 84 of the California State Mining Bureau, to be issued in April, 1919. Various methods of shutting off the top and intermediate waters met with in drilling oil wells were discussed; the data were obtained from 890 reports made to the Department of Petroleum and Gas during the year ending June 30, 1918; the reports were concerned chiefly with new work and deepening operations. The paper discussed the relative efficiency of operations with rotary and cable tools. A comparison of all the data showed that the failure to shut off the water was 14.4 per cent. for cable-tool wells, and 21.8 per cent. for rotary wells. Failures in the rotary wells are in part due to the difficulty of determining the depths of the various formations. It was shown that the rotary method is confined to casing of a limited range in diameter,

the 10-in. being the favorite size, while the casing in cable-tool wells is equally distributed over 8.25 in., 10 in., and 12.5 in. diameters.

One of the advantages of the cement shut-off is probable protection from corrosion. Instances in the Coalinga field were cited where corrosive waters cut out the casing in from 3 to 5 years. Cement shut-off has the further advantage that it reinforces the casing and prevents collapse; it also stops movements of fluids and gases between formations. It may be used for all depths, while formation shut-off is more suitable for shallow wells; 16 per cent. of the cement shut-offs were over 3000 ft. deep. The percentage of failures increases with the depth of the well: 14.9 per cent. at 100 to 1000 ft., 20.4 per cent. at deeper than 3000 ft. In each instance the rotary failures are greater, the excess for all depths being 7 per cent.

W. H. SHOCKLEY, *Secretary.*

COLORADO SECTION

R. J. GRANT, *Chairman* W. H. LEONARD, *Vice-chairman*
ROBERT M. KEENEY, *Secretary-Treasurer*, Box 186, Denver, Colo.
S. A. IONIDES ROBERT HURSH

The regular annual meeting of the Colorado Section of the A. I. M. E. was held at the Denver Athletic Club, Feb. 8, 1919. Fifty-three members attended the dinner. After a talk by Lieut. Horace Wells, of the 104th Squadron, R. A. F., B. E. F., in which he detailed his experience as a prisoner in Germany for 4 months, a business meeting was held. The newly elected officers are named above.

It was found that the treasury of the Local Section was in first-class condition; credit for a good part of the balance on hand is due to the liberality of the Cripple Creek and Colorado Springs members. The appeal for relief of the children of the French engineers was answered by an appropriation of $150 from the treasury; other contributions were made by the members.

The new chairman, R. J. Grant, was the very competent executive manager to Colorado's Food Administrator, Thos. B. Stearns, and the Local Section should benefit through his unusual capabilities.

FRED CARROLL, *Secretary-Treasurer for* 1918.

AFFILIATED STUDENT SOCIETIES

MINING ASSOCIATION, UNIVERSITY OF CALIFORNIA

At a meeting of the Mining Association of the University of California, held Feb. 12, officers for the present semester were elected as follows: President, Richard C. Kerr, '19; vice-president, Glen T. O'Brien, '20; secretary, Kenneth V. King, '19; treasurer, Sam Grinsfelder, '20.

KENNETH V. KING, *Secretary.*

CARNEGIE METALLURGY AND MINING CLUB, CARNEGIE INSTITUTE OF TECHNOLOGY

At a meeting held Jan. 21, by the Carnegie Metallurgy and Mining Club of the Carnegie Institute of Technology, Pittsburgh, Pa., the follow-officers were elected: A. Stratmoen, president; S. H. Stupakoff, Jr., secretary; F. B. Dreifus, treasurer.

A committee was appointed to arrange a schedule of prominent speakers, to be selected particularly from the industries of Pittsburgh, for each meeting of the Club. The first such meeting was held Feb. 3. The speaker, Raymond Wile, a mine owner of Bolivia, gave a very interesting talk on Smelting of Tin Ores in Bolivia, including in his talk his experiences with the natives and also commercial difficulties encountered. His talk was thoroughly enjoyed by all present.

S. H. STUPAKOFF, JR., *Secretary.*

MINING SOCIETY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The officers of the Mining Society at the Massachusetts Institute of Technology are: A. A. Brown, president; V. E. Stevenson, vice-president; J. P. Grilli, treasurer; R. C. Johnson, secretary.

BANQUET ADDRESSES BY PRESIDENTS DOWLING AND JENNINGS*

PRESIDENT DOWLING'S† ADDRESS

I feel that it is a great honor to be invited to reply to this toast on behalf of the Canadian Mining Institute. I wish to thank you for your very cordial reception of the toast and for the sentiments expressed in your invitation to the Institute to coöperate in a series of joint meetings. It is an earnest of the mutual regard which the peoples of the two countries have for each other. We have been allies in a very great war and the feelings of good-will engendered by that alliance will survive, I believe, through the strenuous times of peace. The other nations of the alliance had through many changes in history, fought each other and for each other and had thereby gained a clear conception of the social aims and moral character of their peoples. With this knowledge came mutual trust—the one element necessary for united action or lasting agreement. On this continent the two peoples are drawn together by bonds of a common origin and, largely, a common language. No war has been necessary to force declarations of national aims on which to base terms of amity. And now our peoples who had studied the arts of peace together have together passed through fire—drawn into the conflict by a like horror at the sacrilege of the crucifixion of the rights of humanity. Their courage and manhood has been tested at Ypres and Chateau Thiery by the great assayer war, and, together, with thankful hearts we see the triumph of right over might and better than ever know that we have the same conception of the government of the people for the people.

We are met to celebrate the close of the association of our brethren at the front in the fight for freedom for the world—a freedom that to us seems natural but which to the majority of the allied nations is a heritage derived from the protest made by the American colonies against German ideas of government of which remnants had until then survived in Great Britain.

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* Addresses delivered at the annual banquet, Hotel Biltmore, Feb. 19, 1919.

† President of the Canadian Mining Institute.

The common heritage of freedom enjoyed by the many units of the present British Empire proved to be a bond which, although almost invisible to German perception, was of the strongest fiber. The act of offering help to the motherland brought to us the realization that as a people we were assuming the responsibilities of a nation and it is this realization which fills us with a modest pride when as members of a new nation within the Empire we are invited to coöperate in your deliberations. We in return offer the hospitality of the Lady of the Snows at our Montreal meeting and let me assure you that the reception will be one that will indicate the beating of a warm heart. Our people are essentially homemakers, our industry is largely agricultural, but our problems in mining and metallurgy, while not on a grand scale, are interesting. We hope to discuss regions of greatly varying topography and climate. Those of you who can attend, will see views of the Arctic coast, of the more southern plains and mountains, and—a theme that has been of common interest since the days of the first crusade—views of the last crusade to the Holy Land under General Allenby. For our own people whose hearts are still with the boys at the front, we shall have the War Records pictures of the last days of the war with the Canadians at the taking of Mons. This city, it will be remembered, was the point at which the first British Army, the "Contemptibles," took their bulldog grip on the German legions.

Again, Mr. Chairman, may I in closing tender on behalf of the Canadian Mining Institute our greetings and our wish for continued cordial relations and a mutual prosperity.

PRESIDENT JENNINGS'* ADDRESS

It is with a very special sense of pride and gratification that I am able to extend to the Canadian Mining Institute a welcome on behalf of the American Institute of Mining and Metallurgical Engineers. Last October, we were lured to Colorado by the tales of its wonderful climate —where it only rained once in 6 months. We were in Colorado Springs four days and took away with us all their bad weather for the next 2 years; but we also took away with us memories of a warm and enduring hospitality that more than made up for the rainy weather. At that time, I invited all our western members to this meeting but pointed out to them that New York had the second worst climate in the United States. New York, the superb, has extended its all-embracing arms in a most hearty welcome and has shown by the bright sunshine obtaining during this meeting that I had maligned her climate. A New Yorker, when he is not a Southerner, is a New Englander, who has gone west and come back to New York. We can under this definition all claim to be New Yorkers.

I am not going to take up in detail the reports of our Secretary and Treasurer, which give you a full account of the work of our Institute.

I want to draw your attention to the numbers of your membership, which now amounts to, I think, 7300, a greater membership than ever recorded in our history. I estimate, however, that there are at least 14,000 people in the United States who as members, associates, or junior associates, should belong to our Institute. That is a figure that we should set as a mark and not rest content until it is achieved. With

* President of the American Institute of Mining and Metallurgical Engineers for the year 1918–19.

the increase in membership, the capacity of the Institute to serve its members will be correspondingly increased.

As far as the financial condition is concerned, I shall only say that we are solvent. This is due, in large measure, to the generosity of one of our Directors who, when it looked as if we would not be able to carry out our plan of remitting the dues of our members in active service, made a large donation, which enabled us to close the year with a balance on the right side. Our budget for the coming year has been conservatively planned and our activities will be confined to our resources.

The work of our members as individuals and the Institute as a whole has contributed to help win the war. The service flag opposite me shows that 845 members wear the uniform of the United States and the Allies; twenty-three are known to have paid the supreme sacrifice. Although exact details are not obtainable, enough is known to be able to state that there are many others. When details are obtainable their names and records will be published in the *Bulletin*.

During the past year I paid a visit to six of our Local Sections, of which there are now fifteen. Our Secretary and our First Vice-president, Mr. Goodale visited several others. The ferment that is stirring all hearts and minds is strongly operating among the engineers. This is natural as Major Yerkes has shown us that in the Army, representing all classes of the community, the engineers were shown to be the most mentally alert and intelligent. I found in many States a movement to found State Engineering Societies, on the order of trade unions, with the idea of obtaining legislation to license engineers to increase the emoluments of the younger men in the profession and to give the engineer more prominence in the community as a man and as a citizen. While I am heartily in sympathy with the last two objects, it does not seem to me that the engineers interested are using the right way to achieve these objects. The Engineering Council, which represents the four national Engineering Societies in matters that concern the relationship of the engineer and the public, is the proper body to take up these questions and has here a great opportunity, which it should utilize to the full.

In this review of the year's accomplishments, I want to give full value to the devoted work of our Secretary. Presidents come and go and are more or less figureheads, but the brains, initiative, and energy that keep our Institute thriving are supplied by our Secretary.

The coming year is full of promise. With the change of name, the activities of a large and increasingly important part of your membership has been recognized. It is hoped that those who previously were unwilling to call themselves mining engineers will find themselves attracted to that scientific society that not only provides them with the class of papers they are interested in discussing but also recognizes them in its name.

Under the strong and skillful guidance of our new President, aided by an interested board of Directors, a devoted Secretary and a loyal membership, the American Institute of Mining and Metallurgical Engineers will increase in numbers and renown.

At these last sessions we have had many papers concerned with what I call "human engineering." Many visions dependent for their beauty on the perfectibility of human nature, in which I ardently believe, have been described in words. May at least some of them be realized during the coming year in deeds.

ATTENDANCE AT THE NEW YORK MEETING

For the first time, the attendance at the meetings of the Institute passed the thousand mark; as is shown by the following table:

	Registered	At Banquet Did Not Register	Total
Men	703	76	806
Women	195	61	256
			1062

The names of the members and guests who registered or attended the banquet but did not register are:

A

C. A. Adams
Thos. J. Adams
Lawrence Addicks
H. T. Abrams
G. Aertsen
M. M. Albertson
James Aldrich
D. C. Alexander, Jr.
W. H. Alexander
A. W. Allen
F. D. Aller
R. H. Allport
F. C. Alsdorf
Capt. M. Altmayer
A. W. Ambrose
Henry M. Ami
F. L. Antisell
R. S. Archer
Paul Armitage
Andrew B. Armstrong
Clifton T. Armstrong
Ralph Arnold
R. M. Atwater, Jr.
Joseph E. Aue
A. M. Austin
W. S. Ayres

B

George H. Bailey
T. F. Baily
H. Foster Bain
S. H. Ball
J. I. Banash
Wilbur Vick Banister
Percy E. Barbour
George D. Barron
J. B. Barragwaneth
Charles H. Bartlett
G. P. Bartholomew
George G. Bassett
D. M. Barringer
W. H. Bassett
Lt. H. Barmore
Edson S. Bastin
Mowry Bates
Alan M. Bateman
A. J. Beatty
A. B. Beaver
Wesley J. Beck
R. E. Bedworth
A. D. Beers
Hans Behr
Edgar G. Bell
Donald A. S. Bell
W. de LeBenedict
G. B. Bertelli
Charles P. Berkey
Clinton Bernard
W. N. Best
Robert M. Betts
Christopher H. Bierbaum
Paul Billingsley
R. A. Bingham
R. M. Bird
John L. W. Birkinbine
G. S. Bisey
Charles W. Boise
J. J. Blackmore
A. E. Blackwood
Capt. C. K. Blatchly
E. L. Blossom
C. A. Bohn
James M. Bonsall
E. E. Boon
Gail Borden
R. S. Botsford
John M. Boutwell
William Spencer Bowen
John Boyd
Henry C. Boynton
Arthur F. Braid
Albert Brann
C. S. Brainin
Frank G. Breyer
Sam D. Bridge, Jr.
Graham Bright
C. B. Bronson
H. J. Brown
Lowell H. Brown
Thos. E. Brown
D. G. Browne
H. Y. Bruddon
C. C. Burger
P. Q. Bullard
E. Z. Burns
John P. Burt
Charles L. Bryden
Arthur Dudley Buzby
Melvin Brugger
George K. Burgess
Christopher L. Bruns

C. L. Bryden
C. D. Burchenal
Charles A. Burdick
A. H. Burroughs, Jr.

C

J. F. Callbreath
William Campbell
R. C. Canby
C. T. Carnahan
Frank D. Carney
H. L. Carr
A. W. Carroll
F. E. Carter
S. N. Castle
R. M. Catlin
H. W. Chadbourne
A. R. Chambey
A. R. Chambers
H. M. Chance
Maj. T. M. Chance
M. Y. Chang
J. Parke Channing
D. E. Charlton
Chester H. Chatfield
S. H. Chauvenet
Wm. R. Chedsey
Chimyang Chen
Wang Chin Chung
Gwilliam H. Clamer
F. E. Clark
J. D. Clark
G. H. Clevenger
Wm. C. Coffin
G. W. Coggeshall
W. B. Cogswell
Ernest H. A. Cohen
Clarence L. Colbert
A. L. Colby
Frank L. Cole
Leon N. W. Colin
F. N. Collins
George L. Collord
G. F. Comstock
E. F. Cone
Eli T. Conner
C. M. Conner
Fred M. Conran
W. Lorrain Cook
G. G. Coolidge
John H. Cooper
L. D. Cooper
M. D. Cooper
S. H. Coors
Frederick K. Copeland
J. Ross Corbin
C. V. Corless
C. R. Corning
W. M. Corse
Eugene Coste
F. G. Cottrell
William A. Coughlan
William A. Cowan
Alfred H. Cowles
Herbert B. Cox
Donald K. Crampton
H. M. Crankshaw
Harrison W. Craver
Barton Cruikshank
P. R. Croll
Robert H. Cromwell
George C. Crossley
John J. Crowe
William R. Culver
W. L. Cumings
James J. Curran

D

Capt. E. O. Daue
D. B. Daly
Eugene H. Dawson
W. W. Davis
G. M. Davids
G. M. Davidson
Philip Davidson
R. W. Deacon
W. A. Deane
W. V. De Camp
E. S. Dewey
Karl De Laittre
B. W. De Long
S. L. F. Deyo
Theodore C. Denis
Frederic P. Dewey
Walter S. Dickson
G. G. Dieffenbach
Charles E. Dinkey
Joseph L. Dixon
William Donald
H. E. Dodge
George A. Dornin
J. V. N. Dorr
G. H. Dorr
Charles Dorrance
D. B. Dowling
David Dows
Henry S. Drinker
Waldemar Dyrssen
George D. Dub
Capt. Boyd Dudley, Jr.
S. Dufault
Ralph Donald
P. H. Dudley
E. Dulieux
C. B. Dunster
Francis Bird Dutton
Theodore Dwight

E

H. Y. Eagle
S. Ford Eaton
Howard N. Eavenson
Capt. H. W. Edmondson
C. Wesley Edwards
George J. Egan
Cranford Elliott
W. Ellis
K. F. Eilers
Karl Eilers
E. H. Emerson
N. H. Emmons, 2d
Thomas M. Eynon

F

S. E. Fairchild, Jr.
Paul V. Faragher
C. Mason Farnham
L. D. Faunce
F. W. Feiker
Philip Feldman
Charles Ferry
B. E. Field
Thorold F. Field
W. H. Finkeldey
O. S. Finnie
Henry S. Fleming
Capt. J. P. Fleming
R. Fleming
Alfred D. Flinn
Thomas C. Flinn
O. F. Flumerfelt
T. J. Flynn
Francis B. Foley
George C. Foote
H. H. Forbes
Fedor F. Foss
H. W. Fox
Colin G. Fink
Lewis W. Francis
R. E. Frickey
Lawford H. Fry
T. S. Fuller
Dwight Furness

G

Paul W. Gaebelein
H. F. E. Gamm
Herman Garlichs
F. Lynwood Garrison
Emil Gathmann
W. B. Gero
Thos. W. Gibson
G. W. Gibson
Philip L. Gill
George H. Gilman
Thomas Gilmore, Jr.
Federico Giolitti
George McM. Godley
T. E. Godson
H. Golden
C. W. Goodale
L. H. Goodwin
S. J. Gormly
W. D. Gordon
Alexandre Gouvy
T. A. Gowling
Capt. Walter Graham
W. F. Graham
L. C. Graton
P. G. Grant
J. S. Gravely
J. H. Gray
H. L. Greene
Lieut. Donald Greenleaf
Herbert C. Gregory
John Griffin
H. L. Griggs
C. C. Griggs
Robert Grimshaw
George G. Griswold
Frank Groch
Alden O. Groff
Charles Grubmeyer
Justice F. Grugan
E. L. Gruver

H

A. M. Hageman
A. W. Hahn
Clarence M. Haight
A. Gage Hall
R. Dawson Hall
E. J. Hall
John H. Hall
R. D. Hall
R. L. Hallett
William Hamilton
Lafayette Hanchett
N. J. Hansen
H. W. Hardinge
Norman G. Hardy
Benjamin G. Harmon
Harry G. Harrington
W. S. Harper
Gilbert Hart
Claude Hartford
Robert Harvie
Henry E. Haws
R. A. Hayward
Alf. G. Heggem
A. A. Heimrod
Philip W. Henry
J. B. F. Herreshoff
James B. Herreshoff, Jr.
E. G. Hewlett
Henry D. Hibbard
W. R. Hibbard
Myron F. Hill
Ralph T. Hirsh
F. B. Hitchcock
H. M. Hobart
R. E. Hobart
A. S. Hoffman
Lieut. Lloyd Hoffman
Ross B. Hoffman
W. P. Hoffman
H. O. Hofman
E. A. Holbrook
Levi Holbrook
G. C. Holder
G. S. Holmquist
L. S. Holstein
B. B. Hood
W. E. Hopper
Reginald E. Hore
R. R. Hornor
E. O. Hovey
L. E. Howard
H. M. Howe
Raymond M. Howe
Samuel L. Hoyt
D. R. Hull
George S. Humphrey
Alex. C. Humphreys
Louis D. Huntoon

Robert Hursh
J. P. Hutchins
F. Hutchinson
W. Spencer Hutchinson
R. W. Hyde

I

William Morris Imbrie, Jr.
D. G. Irions
Mr. Iredell

J

Herbert E. Jackman
Luis Jackson
A. H. Jackson
Floyd D. James
A. H. Jameson
William R. Jarvis
Zay Jeffries
Charles V. Jenkins
Sidney J. Jennings
J. E. Johnson, Jr.
Roswell H. Johnson
Jesse L. Jones
Wilber Judson

K

Julius Kahn
S. Kato
Charles H. Keefer
A. F. Keene
Samuel M. Keiper
Edward Keller
Walter H. Kelley
James F. Kemp
D. J. Kennedy
J. E. Kennedy
E. F. Kenney
William Kent
Edward F. Kern
John B. Kerr
Z. Kimura
H. Kingsmill
F. O. Kichline
E. B. Kirby
Walter P. Klugescheid
I. N. Knapp
C. W. Knight
L. L. Knox
Alexander Knut
Arthur Koenig
B. Koleroff
John A. Korsovkeen
Paul Kovaloff
Theodore Krempabery
L. J. Krom
P. Kraft, Jr.
Henry Krumb
George F. Kunz
George J. Kwasha

L

D. B. Lake
Thomas Lamb
W. H. Lanagan
R. R. Landon
W. H. Landers
J. S. Laner
A. J. Lansa
Thomas R. Lawson
B. B. Lawrence
Clement LeBoutillier
Albert R. Ledoux
H. A. Levey
S. LeFevre
J. Volny Lewis
Robert Linton
Capt. Donald M. Liddell
John W. Lieb
John Orth Liebig
J. M. Lilligren
T. H. Liggett
L. B. Lindemuth
W. Lindgren
Charles Lindmueller
William J. Linn
Clarence P. Linville
James E. Little
James M. Little
R. L. Lloyd
Robert T. E. Lozier
A. F. Lucas
Edwin Ludlow
Dorsey A. Lyon

M

D. S. McAfee
Paul McAllister
J. F. McClelland
K. W. McComas
R. E. McConnell
W. E. McCourt
E. P. McCrorken
C. A. McCune
J. Spotts McDowell
C. H. McDowell
E. J. McDonnell
P. W. McDonnell
J. B. McGraw
P. M. McHugh
John Stuart McKaig
Robert J. McKay
B. E. McKechnie
W. B. McKinlay
P. E. McKinney
A. H. McLane
Donald H. McLaughlin
A. McLaren
W. D. McMillan
John McLeish
W. C. Phalen
C. E. McQuigg
P. G. McVetty
A. S. MacDowell
Charles H. MacDowell
Van H. Manning
A. D. Marriott
C. W. Marsh
H. Martin
H. K. Masters
Francis Mataoredona
J. A. Mathews

C. H. Mathewson
E. P. Mathewson
A. B. Maxwell
Lucius W. Mayer
E. A. Maynard
A. Chas. Meagher
H. A. Megraw
Carl A. Meissner
Charles R. Meissner
Samuel Melitzer
M. H. Melin
Paul D. Merica
A. W. Merrick
Alden Merrill
Mansfield Merriman
T. C. Merriman
Hubert Merryweather
Joseph A. Meyerovitch
Benjamin L. Miller
E. T. Miller
Rudolph P. Miller
S. W. Miller
W. B. Miller
Willet G. Miller
William Millward
Alexander Milyko
W. G. Mitchell
Maynard Mizel
Richard Moldenke
Claude D. Moll
J. C. Montgomery
J. F. Mooney
Edward T. Morris
H. F. Moore
Philip N. Moore
H. C. Morris
James G. Morrow
H. E. Morse
H. Mortimer-Lamb
P. A. Mosman
Ichiro Murai

N

Lieut. H. C. Neal
Arnold Neilsen
John H. Nelson
A. Neustaedter
C. Seymour Newcombe
D. H. Newland
Edmund Newton
J. C. Nicholls
Arvid E. Nissen
R. V. Norris
W. H. Norrington
E. G. Norton

O

John H. O'Brien
Herbert G. Officer
E. E. Olcott
Louis W. Olson
F. N. O'Neil
George A. Orrok
F. W. Osborn
Mariano Osmena
V. E. Ottobre

P

L. S. Panyity
D. J. Parker
E. W. Parker
J. Heber Parker
Howard C. Parmelee
W. F. C. Parsons
Morris Pastconak
N. K. B. Patch
S. B. Patterson, Jr.
R. L. Pattinson
Capt. T. A. Patton
J. W. Paul
R. B. Paul
W. H. Paul
C. G. Peattie
Edmund C. Pechin
C. Lee Peck
Robert Peele
W. C. Peterson
Arthur Phillips
Charles C. Phelps
George H. Phelps
H. M. Pier
F. O. Pierce
J. C. Pickering
S. H. Pitkin
Norman B. Pilling
George Prochaska
Wm. B. Price
J. H. Polhemis
W. T. Price
R. Porter
Table Press
Francis R. Pyne
J. N. Pyster

R

W. C. Ralston
Charles F. Rand
Howard Rand
Henry Rawdon
R. M. Raymond
W. W. Raymond
Capt. J. Burns Read
T. H. Rea
Thomas T. Read
R. E. Reed
David B. Reger
Edwin S. Reid
W. L. Remick
M. L. Requa
J. V. W. Reynders
J. Edgar Rhoads
Jos. W. Richards
Robert H. Richards
T. A. Rickard
F. E. Ricketts
Guy C. Riddell
J. B. Riefkin
Edward J. Rigby
Major George C. Riley
Jas. J. Riley
C. R. Rinehart
Harold J. Roast
R. T. Roberts

Thomas Robins
Burr A. Robinson
W. F. Rochow
George B. Rodgers
Keith R. Rodney
Allen H. Rogers
E. M. Rogers
John Roger
Gabriel E. Rohmer
Sidney Rolle
E. P. Ross
Lewis G. Rowand
H. H. Rowatt
P. H. Royster
F. T. Rubidge
W. E. Ruder
David B. Rushmore
William Russell
Forest Rutherford
George M. Ryall
C. F. W. Rys

S

W. D. Sargent
H. Satoh
Walter M. Saunders
Leslie Savage
L. W. Schad
W. A. Schlesinger
Henry K. Schoch
Jesse Scobey
Howard Scott
S. Secard
I. Schilowsky
John M. Sebenius
Frederic G. Sefing
William Seguine, Jr.
F. F. Sharpless
E. W. Shaw
F. M. Shaw
H. A. Shaw
William H. Shearman
W. R. Shimer
L. B. Shipley
E. M. Shipp
A. T. Shurick
Elwood D. Shuster
A. B. Shutts
Morris Siegel
E. L. Sifton
Alexander Silverman
R. E. Simpson
W. E. Simpson
Joseph T. Singewald, Jr.
J. A. Singmaster
Lt. W. H. W. Skerrett
C. E. Skinner
E. N. Skinner
S. Skowronski
H. Souder
Lt. E. A. Slatin
Arthur Bessey Smith
Veleair C. Smith
William Allen Smith
Henry B. Smith
J. William Smith
C. R. Spare
Chas. S. Speigelberg
F. N. Speller
Frank N. Spencer
H. N. Spicer
H. G. Spilsbury
E. G. Spilsbury
A. D. Sproat
K. C. Stadtmiller
Mr. Stadler
A. A. St. Aubin
W. H. Staver
Theron D. Stay
L. D. Stay
Lt. C. M. Stebinger
Eugene Stebinger
Paul Sterling
Douglas B. Sterrett
A. A. Stevenson
D. M. Stevenson
Leighton Stewart
R. K. Stockwell
C. H. Stokesbury
J. C. Stoddard
George C. Stone
Bradley Stoughton
E. S. Strang
Fred Strauss
L. B. Sturgis
Joseph Struthers
Edward B. Sturgis
W. P. Sykes

T

Yoshiichi Tado
M. Gardner Talcott
C. H. Taylor
John C. Taylor
Knox Taylor
L. H. Taylor, Jr.
Roger Taylor
S. A. Taylor
Arthur Thacher
B. B. Thayer
Kirby Thomas
Marion L. Thomas
E. E. Thum
Benjamin F. Tillson
Herbert A. Timmons
William Essen Tizard
S. Topereff
Henry Traphagen
C. S. Trewin
M. R. Trimmer
Capt. H. D. Trounce
C. E. Trube
G. A. Trube
Capt. W. J. Turner
H. Tsai
L. S. Twomey

U

Joseph L. B. Umpleby
J. S. Unger
Louis Unger

V

S. G. Valentine
G. D. Van Arsdale
Ernest Vascimimi

W

A. J. Wadhams
Leonard Waldo
Col. Waite
W. B. Waldo
M. S. Walker
Arthur L. Walker
H. L. Wallan
H. A. Walter
Dr. C. C. Wang
Raymond Walter
Arthur T. Ward
C. M. Warner
R. C. Warriner
S. D. Warriner
C. D. Warriner
J. B. Warriner
R. B. Watson
W. Watson
A. P. Watt
C. W. Washbourne
Louis P. Webert
William R. Webster
H. H. Webb
F. R. Weekes
D. A. Welch
Major George S. Weinberg
H. K. Welch
E. A. Weinberg
C. M. Weld
D. A. Welet
H. W. Weller
Howard P. Welley
Carl A. Wendell
Roger L. Wensley
George C. Westley
William Young Westervelt
F. A. Weymouth
H. H. Whitcomb
W. DeWhyte
Major A. E. White
Lowe Whiting
David White
Alfred R. Whitman
H. L. Whittemore
M. A. Whiting
Major L. W. Wickes
M. H. Wickhorst
Raymond S. Wile
William H. Wiley
R. D. Willets
E. J. Will
C. E. Williams
David Williams
F. P. Williams
G. E. Williams
Fred L. Wolf
J. D. Wolfe
H. C. Wilmot
H. M. Wilson
Horace V. Winchell
A. K. Wood
Capt. Harold F. Wood
Henry E. Wood
T. S. Woodward
Felix E. Wormser
William L. Wotherspoon
Jos. Writer
R. B. Wurlitzer
Henry Wysor
D. C. Wysor
R. J. Wysor

Y

Masayoshi Yano
Robert M. Yerkes
George J. Young
Pope Yeatman
James M. Zilboorg

The women who registered are:

A

Mrs. A. W. Allen
Bessie M. Aller
Mrs. James Aldrich
Mrs. W. H. Aldridge

B

Mrs. J. S. Baird
Mrs. Percy E. Barbour
Mrs. George D. Barron
Mrs. Barragwaneth
Mrs. H. Foster Bain
Mrs. W. H. Bassett
Mrs. Charles P. Berkey
Mrs. D. M. Beal
Miss Alice Bell
Miss Edith Benjamin
Mrs. W. A. Best
Miss Hazel Brunner
Mrs. Ed. L. Blossom
Mrs. Arthur F. Braid
Mrs. S. H. Ball
Mrs. C. L. Bryden
Mrs. Bullard
Mrs. Boyd
Mrs. I. E. Burdick
Mrs. Burger
Miss L. Bridge

C

Mrs. Herbert Cox
Mrs. R. M. Catlin
Miss Catlin
Miss Catlin
Mrs. A. R. Chambers
Mrs. C. M. Conner
Mrs. W. E. Carroll
Mrs. A. W. Carroll
Miss Conner
Mrs. W. C. Coff
Mrs. F. G. Cottrell
Mrs. F. D. Carney

Mrs. Alfred H. Cowles
Mrs. M. E. DeCamp
Mrs. H. W. Cranshaw
Mrs. A. H. Catlin
Mrs. J. C. Conway
Mrs. William Campbell
Miss Virginia R. Chauvenet
Mrs. A. C. Chenoweth
Mrs. W. C. Coffin
Miss Mary Coffin
Mrs. Ernest H. A. Cohen
Mrs. J. H. Cooper
Mrs. M. D. Cooper
Mrs. Wm. A. Cowan
Mrs. W. L. Cumings

D

Mrs. R. W. Deacon
Mrs. G. M. Davidson
Mrs. Lewis K. Davis
Mrs. H. S. Drinker
Miss Antoinete N. Dorr
Mrs. H. E. Dodge
Mrs. D. B. Dowling
Mrs. Francis Bird Dutton
Mrs. Boyd Dudley, Jr.

E

Mrs. Emerson
Mrs. M. L. Edmundson
Mrs. Thomas Eynon
Miss E. Gunner
Mrs. H. L. Ellinwood
Miss L. Erskine
Miss Eilers
Mrs. K. Eilers

F

Miss Frances G. Fulton
Mrs. Fedor F. Foss
Mrs. Colin G. Fink
Mrs. O. S. Finnie
Mrs. Thomas C. Flinn
Mrs. H. H. Forbes

G

Mrs. H. Garlichs
Mrs. J. Grugan
Miss Maria Luisa Giolitti
Mrs. Giolitti
Miss E. B. Godson
Mrs. L. H. Goodwin
Mrs. C. C. Griggs
Mrs. L. C. Graton
Mrs. E. L. Gruver
Miss Green

H

Mrs. J. P. Hutchins
Mrs. R. E. Hobart
Mrs. Henry D. Hibbard
Mrs. Phillip W. Henry
Mrs. C. B. Hickok
Mrs. C. M. Haight
Mrs. B. B. Hood
Mrs. Agnes B. Hoffman
Mrs. W. P. Hoffman
Mrs. K. Hoffman
Mrs. C. F. Hoffman
Mrs. George S. Humphrey
Mrs. Lafayette Hanchett
Miss Helen Hanchett
Miss Jane Hyde
Mrs. Hyde
Miss L. Hyde
Mrs. R. L. Hallett
Mrs. Benjamin G. Harmon
Mrs. A. G. Heggem
Mrs. H. M. Howe
Mrs. L. D. Huntoon
Mrs. L. Holbrook

I

Mrs. Axel O. Ihlseng
Miss Olga Ihlseng

J

Mrs. Zay Jeffries
Mrs. Sidney J. Jennings
Miss Amy Sidney Jennings
Miss Mary A. Jennings
Mrs. C. V. Jenkins
Mrs. J. B. Herreshoff, Jr.
Mrs. J. E. Johnson
Mrs. W. Judson
Mrs. Jackson
Mrs. J. E. Jones

K

Mrs. L. L. Knox
Mrs. Henry Krumb
Mrs. J. F. Kemp
Miss Kemp
Mrs. P. M. Kenney
Mrs. Kingsmill
Mrs. E. Koenig
Mrs. P. Kraft, Jr.
Mrs. Kelly
Miss Bessie H. Kunz
Mrs. A. F. Keene
Mrs. F. O. Kichline

L

Mrs. D. M. Liddell
Mrs. T. H. Liggett
Mrs. J. E. Little
Miss Leach
Mrs. B. B. Lawrence
Miss Lawrence
Mrs. Edwin Ludlow
Mrs. A. C. Ludlum
Mrs. Mark R. Lamb
Miss Virginia Lamb
Mrs. W. H. Landers

M

Mrs. R. E. McConnell
Mrs. P. McDonnell
Mrs. P. E. McKinney
Mrs. D. S. McAfee
Mrs. J. C. McGill
Mrs. W. D. McMillan
Mrs. A. McLaran

Mrs. J. A. Mathews
Mrs. E. P. Mathewson
Mrs. W. Mein
Miss Carroll Macy
Mrs. Richard Moldenke
Mrs. T. H. Marquis
Mrs. H. Marsh
Mrs. L. W. Mayer
Mrs. T. C. Merriman
Mrs. Morey
Mrs. H. C. Morris
Miss E. E. Morse
Mrs. W. D. McMillan
Mrs. H. K. Masters
Mrs. J. A. Meyerovitch
Mrs. L. Morganroth
Mrs. A. C. Meagher
Mrs. Verae Minich

N

Mrs. Newcomb
Mrs. D. H. Newland
Mrs. Neustaedter
Miss Neustaedter
Mrs. H. C. Neal

O

Mrs. Louis W. Olson

P

Mrs. P. W. Palmer
Mrs. H. C. Porrior
Mrs. Hugh Park
Mrs. E. H. Parker
Mrs. J. H. Polhemis
Mrs. J. C. Pickering
Mrs. H. C. Parmelee
Mrs. W. F. C. Parsons
Mrs. R. L. Pattinson
Mrs. S. H. Payne
Mrs. Wm. B. Price
Miss Lillian Pursell
Miss Alice Putman

R

Mrs. T. H. Rea
Mrs. R. E. Read
Mrs. R. M. Raymond
Mrs. L. G. Rowand
Mrs. P. Rovaloff
Mrs. E. P. Ross
Miss Mary Rogers
Mrs. G. C. Riddell
Mrs. B. A. Robinson
Mrs. J. W. Richards
Mrs. David B. Reger
Mrs. G. B. Rodgers
Mrs. Sidney Rolle
Mrs. Allen H. Rogers
Mrs. George M. Ryall
Mrs. R. H. Richards
Mrs. T. T. Read
Mrs. J. V. W. Reynders
Mrs. Gabriel E. Rohmer
Mrs. Thomas Robins

S

Mrs. C. H. Stokesbury
Mrs. Smith
Mrs. Leighton Stewart
Mrs. W. H. Staun
Miss Struthers
Mrs. E. T. Struthers
Mrs. L. B. Sturges
Mrs. F. N. Speller
Mrs. H. N. Spicer
Mrs. Harrison Souder
Mrs. Emmett Smith
Mrs. Jesse Merrick Smith
Mrs. H. G. Spilsbury
Mrs. Jesse Scobey
Mrs. Paul Sterling
Mrs. Stone
Mrs. Stadler
Mrs. R. K. Stockwell
Miss B. Spilsbury
Miss W. Smith
Mrs. F. F. Sharpless
Mrs. E. M. Shipp
Mrs. W. R. Shimer
Mrs. Frank Stanfield

T

Mrs. John C. Taylor
Mrs. B. F. Tillson
Miss Louise Talbot
Mrs. M. L. Thomas
Mrs. H. D. Trounce

V

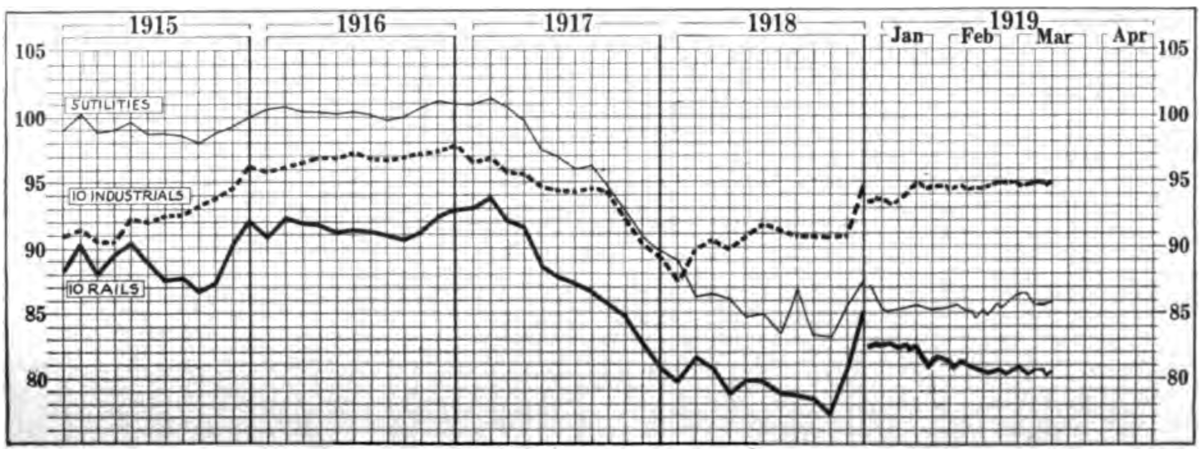
Mrs. George Vitz

W

Mrs. Leonard Waldo
Miss Ruth M. Waldo
Mrs. C. D. Warriner
Mrs. P. C. Warriner
Mrs. J. B. Warriner
Mrs. C. M. Warner
Mrs. R. B. Watson
Mrs. W. Watson
Mrs. Waite
Mrs. F. R. Weeks
Mrs. George S. Weinberg
Mrs. L. W. Wickes
Mrs. H. V. Winchell
Mrs. Wm. Y. Westervelt
Mrs. B. Wolfe
Mrs. R. J. Wysor

Trend of Bond and Stock Markets

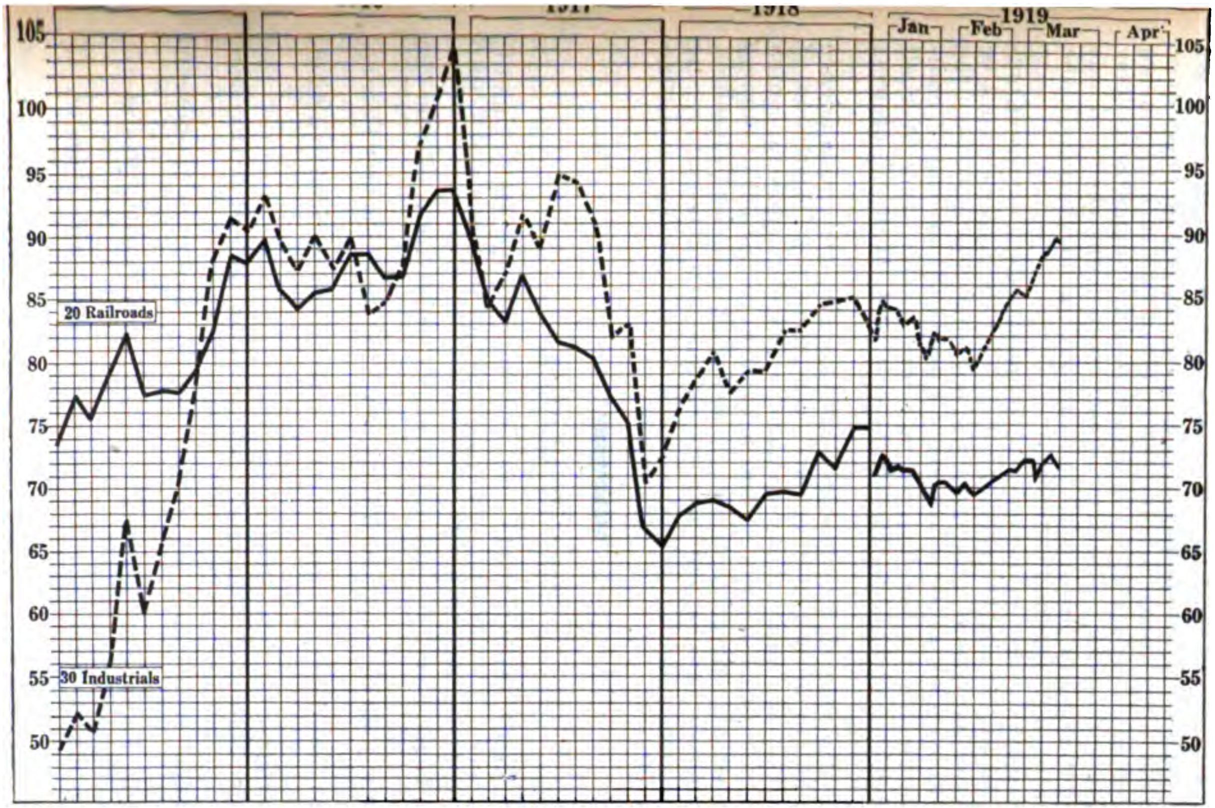
For the benefit of those of our members who are considerable holders of securities, but owing to their isolated situations are not in close touch with the metropolitan market and current quotations, we are publishing



PRICE TREND OF NEW YORK BOND MARKET

This graph shows the average prices of ten railroad, ten industrial and five public utility bonds on the first business day of each month from January, 1915, to December, 1918, and the weekly fluctuations since January 1, 1919.

two very interesting graphs, showing the course of the bond and stock markets in New York over a long period. These graphs are furnished through the courtesy of the financial department of the New York *Tribune*.



Price Trend on New York Stock Market

This graph, shows the average prices of twenty railroad stocks in one line and thirty industrial stocks in the other on the first business day of each month from January, 1915, to December, 1918, and the weekly fluctuations since January 1, 1919.

WORK OF NATIONAL SERVICE COMMITTEE

On Jan. 1, the office of the National Service Committee was established at 502 McLachlen Building, Washington, D. C. The first work was to review current legislative information, which is being continued and good results are accomplished. Whenever matters of importance appear in the Congressional Record, notice thereof with such documents as are germane are forwarded to the members of the committee for their information and advice. The first formal report of the chairman was on the so-called Smith-Howard bill to secure Federal endowment for the establishment of engineering research.

The chairman of the Committee, at the request of the Executive Committee of the Engineering Council, appeared before the Senate Committee on Education and Labor for the purpose of opposing those features of the so-called Kenyon bill which would create a practically permanent commission dominated by the Engineering Corps of the Army over all Federal engineering projects as well as state and municipal projects receiving Federal aid.

The greater part of the time has been expended in correspondence and consultation on the matter of the establishment of a Department of Public Works. The results of this work lead to the belief that there is much promise of the establishing of such a department by the 66th Congress if all members of engineering societies, as well as the societies themselves, will unanimously agree on and support a measure, and in order to secure such unanimous support, it will be advisable to call a conference of engineering societies.

DIED IN SERVICE

Bailey, Lewis Newton, Master Engineer, Senior Grade, 4th Regiment, U. S. Engineers, Headquarters Company, died of pneumonia at Camp Merritt, N. J., on Apr. 30, 1918.

Baird, Louis, Lieut., Royal Field Artillery, British Army, died on the battlefield in 1915.

Ballamy, John H., Capt., 103d Engineers, killed in action near Fismes, Aug. 9, 1918.

Bowles, Martin F., 2d Lieut., Co. B., 355th Infantry, killed in action, Sept. 3, 1918.

Burt, Andrew, died in active service, 1916.

Carlisle, Stanley B., Machine Gun Battalion 346, 91st Division, U. S. A., died in France on Oct. 24, of pneumonia.

Cobeldick, William Morley, Royal Engineers, died from gas poisoning on Oct. 7, 1915.

Dougall, Ralph, 4th University Co., Princess Patricia Regiment, killed in action early in the war.

Evans, Alfred Winter, Lieut.-Col., New Zealand Rifle Brigade, D. S. O., D. C. M., killed in action on Oct. 12, 1917.

Gordy, Sheppard B., died in Service, Oct. 9, 1918.

Gorman, Thomas C., Lieut., Canadian Engineers, killed in France, Mar. 18, 1918.

Hague, William, 1st Lieut., Engineer Officers' Reserve Corps, died in active service, Jan. 1, 1918.

Hall, William T., Capt., Royal Flying Corps, killed in action, May 19, 1917.

Harbach, Herbert Moore, died of pneumonia, 1918, at Camp Meade, Md.

Heine, Bernhardt E., Lieut., Aviation Service, died from accident at Fort Sill, Okla., Aug. 10, 1918.

Irving, John Duer, Capt., 11th Engineers, A. E. F., died July 26, 1918, while on active service in France.

Lang, Sidney A., Lieut., Canadian Engineers, died Oct. 6, 1918, of influenza, at the Engineers' Training Depot, St. Johns, Quebec.

Lunn, Robert, Jr., Battalion Runner, 16th Battalion, Canadian Scottish, killed in action, Oct. 1, 1918.

Ohnsorg, Norman Lloyd, died of pneumonia, Oct. 11, 1918.

Perry, Edward H., 1st Lieut., Co. D, 6th Regiment Engineers, U. S. Expeditionary Forces, France, killed in action on March 30, 1918.

Pretyman, Frank Remington, 2d Lieut., Royal Engineers, killed in action on June 17, 1916.

Reece, Fred. B., Capt., Royal Engineers, B. E. F., 232d Army Troops Co., killed in action.

Ringlund, Soren, Medical Department, Fort Logan, Colo., died suddenly in camp on July 24, 1918.

Roper, George, Jr., Lieut., Royal Flying Corps, killed in aeroplane accident in England on May 25, 1918.

Smyth, Raymond Weir, died of influenza at the Navy Yard Hospital, League Island, Philadelphia, Sept. 27, 1918.

UNITED ENGINEERING SOCIETY

The regular meeting of the Trustees of United Engineering Society was called to order at 4 P. M. Thursday, Feb. 27, 1919, in the Board Room of the American Society of Civil Engineers, Engineering Societies' Building, New York. Minutes of a joint meeting of the Finance Committee of United Engineering Society with finance committees of Founder Societies on Feb. 14, were presented. The President called attention to actions relating to the recataloging of the Library and the support of Engineering Societies Employment Bureau of Engineering Council. The activity of the Employment Bureau was approved and support by the Societies informally assured.

In response to a communication from the Fifth Avenue Association, the Secretary was instructed to write favoring the continuance of the daylight saving law.

As to recataloging of Engineering Societies Library, it was announced that the Mining, Mechanical, and Electrical Engineers had voted appropriations, as requested, and the action of the Civil Engineers was awaited.

A list of applications for offices in Engineering Societies' Building, revised to Feb. 27, was read, showing requests for a total of 29 rooms. The President stated that a decision must be reached soon as to what reply shall be made to these applications.

Charles F. Scott, one of the original trustees, who was present, remarked upon the growth of United Engineering Society and his satisfaction at its success.

Alfred D. Flinn, *Secretary*.

ENGINEERING SOCIETIES EMPLOYMENT BUREAU AIDS RETURNED SOLDIERS

During the past 60 or 90 days, the metropolitan newspapers have published much concerning unemployment throughout the nation and the efforts of the Army and various other bureaus for finding work for the returning soldiers. The United States Employment Service has 2000 bureaus throughout the country, which Nathan A. Smyth, Assistant Federal Director, states have placed more than 2,400,000 persons in employment.

The Engineering Societies Employment Bureau, which, since December, 1918, has been endeavoring to put all returning engineers in touch with employers who need efficient men, has produced results that are very gratifying to the Secretaries of the four Founder Societies under whose direct management the Bureau operates. During this period, 1615 men have registered at the Bureau's office in the Engineering Societies Building; not all of these, however, are unemployed. Many are ex-army and navy men, who in passing through New York on their way home, look over the field in the hope of making a change for their own benefit before returning to their former positions. During this period, 427 positions vacant have been filed, 230 of which positions have been filled from the men registered. The letters mailed by this Bureau amount to about 1000 a month and the number of personal calls at the office, 1600. The lowest number of positions filled has been in mining, but the lowest number of registrations is also from mining men.

While in February idleness throughout the nation was increasing at the rate of 35,000 a week, under date of Mar. 7, Arthur Woods, a special assistant to Secretary of War Baker, states that there is a material improvement in the unemployment situation and that the problem is no longer a serious one. It is recognized that the improvement wrought in each individual by his military training and experience has so increased his value that it is not only unfair to ask these men to accept their old jobs at the old wages, but it is probably very unlikely that they will be willing to do so. This plain statement of improvement may not carry conviction to everyone but a concrete example will show its validity. Take the example of a young man under 21, bright and intelligent, with only a high-school education who was employed, before being drafted, on purely manual labor. He shows up well under military training and is made a corporal; he makes good and is appointed a sergeant; and finally becomes top sergeant, which requires him in many ways to handle the entire company of 250 men. The result is, even if he has not been tried by the fire of battle, he comes out of the army with a feeling of self-confidence and capacity that was entirely lacking when he went in and he has had actual experience in handling a larger body of men than the average mine foreman at twice his age, and he has had twice the average amount of detail work to take care of.

The same improvement is true among the officers. The employer is getting a better man back out of the army than he put in and he should be prepared to pay for it and criticism should not be leveled at the men who, feeling their mental and physical improvement, are reluctant to return to old and narrow lines of work.

It was announced, on Mar. 8, that Major General Leonard Wood had been relieved as Commander of the Central Department of the Army at

Camp Funston, Kan., and had accepted an appointment as a member of the executive committee of the Labor Bureau at Chicago, which is a department of the Federal Employment Agency for returning soldiers and sailors to profitable employment.

A. I. E. E. MIDWINTER CONVENTION

About 1300 members and guests attended the Seventh Annual Midwinter Convention of the American Institute of Electrical Engineers, which was held in the Engineering Societies' Building, New York, on Feb. 19 to 21. The opening session was a joint session with the American Institute of Mining Engineers, when welding was discussed. The various phases of standardization in engineering work were discussed by President Comfort A. Adams at the Thursday morning session. Thursday afternoon was spent in visiting. Some of the guests visited the Brooklyn Navy Yards, where they inspected the power plant, shops, dry docks, etc.; others visited the Bell System Laboratories of the Western Electric Co. The papers at the various technical sessions provoked considerable discussion.

COMMISSION OF MINING EXPERTS TO VISIT FRANCE AND BELGIUM

Secretary of the Interior, Franklin K. Lane, has appointed a commission of five mining and metallurgical experts from the Bureau of Mines and the Geological Survey to visit Europe to observe and study reconstruction methods in the devastated regions of France and Belgium. The chairman of the commission is Dr. Frederick G. Cottrell, chief metallurgist of the Bureau of Mines. The other members are: George S. Rice, the chief mining engineer of the same bureau; Frank H. Probert, consulting engineer of the bureau, and professor of mining in the University of California; F. J. Cameron, consulting chemist of the bureau and expert on potash matters; and Hoyt S. Gale, of the Geological Survey, another expert on potash.

AMERICAN WELDING SOCIETY AND BUREAU OF WELDING*

In opening the meeting I wish to express my greatest pleasure at being able to greet this joint session of the Mining and Electrical Engineers. As engineering develops, we find that the border lines between the different branches of engineering become more and more indistinct; the several fields overlap so much that they are three or four layers deep in places. It is only an accident that we couldn't have had the Mechanical Engineers also as a formal part of this gathering, because they are quite as much interested in this subject as the Electrical or Mining Engineers.

A little history may enlighten some of those who have not been close to this work. A year ago last summer, there was brought to the attention

* Abstract of the address of Prof. Comfort A. Adams, President of the American Institute of Electrical Engineers, when opening the joint session on electric welding, Wednesday, Feb. 19, 1919.

of the Standards Committee of the American Institute of Electrical Engineers the desirability of standardizing welding apparatus and the great possibilities in the application of welding to shipbuilding. A subcommittee of the Standards Committee was appointed to investigate these possibilities.

Later, the support of the Emergency Fleet Corpn. was obtained and a nucleus of the Welding Committee was appointed. This Committee, as finally expanded, involved approximately 150 of the ablest men of the country, not only on the electrical but also on the metallurgical side. The work of the Committee expanded with its membership, until I think it is fair to say that the development in the art during the past year is at least equivalent to that of the 10 years previous; for although excellent work had been done before, the "reason why" of welding had never been sifted out with any degree of thoroughness.

At the request of the Emergency Fleet Corpn. a cast-steel anchor chain was developed, largely by and at the expense of the General Electric Co., which proved vastly superior to the old wrought-iron chain. The test specifications for this chain are 40 per cent. higher than for the old wrought-iron chain; it is cheaper to manufacture, and in every way superior, not only in tensile strength, but in shock strength. So I feel some little pride on behalf of the Committee, and of those who have given so generously of their time and talent in connection with the development of this chain.

Since the truce was signed, the Emergency Fleet Corpn. has adopted a policy of contraction and on the last day of January withdrew its support from the Welding Committee. This welding work is to be carried on by the American Welding Society and the American Bureau of Welding, the latter being a joint welding department of every organization in this country that is interested in that subject. The Board of Directors of this Welding Bureau will have representatives from all of the engineering societies, or even industrial organizations which are interested, as well as from Government departments.

INDUSTRIAL BOARD OF DEPARTMENT OF COMMERCE

The Industrial Board of the Department of Commerce has been formed under the chairmanship of George N. Peek, formerly vice-chairman of the War Industries Board. This Board is to put into practical effect a program for the readjustment of prices for basic materials in such a fashion as to create a firm foundation on which the consumer can base his future purchases, and the producer can form necessary estimates. It has the assistance of the Council of National Defense.

One of the first steps of the Board was to call into conference the leaders of industry. At these conferences the general conditions of the country are carefully considered and an effort made to determine and understand the principles that should be applied to permit the successful solution of the problem.

It will be the endeavor of the Board to act promptly by consulting and interchanging views with these representatives of industry in the fullest and freest manner possible with a view to aiding and assisting industry in general to resume activities to the fullest practicable extent.

The immediate object is to bring about such reduced prices as will bring the buying power of the Government, including the railroads, telephones, and telegraphs, into action and make it possible for the Government to state that it is willing to be a buyer for its needs at the reduced prices. If these conferences result in such an understanding on the part of the Government with respect to the important basic industries concerning proper prices and bases for prices at which purchases may be made by it, and these are approved by the Board, it is believed that upon announcement thereof to the country in general the public will feel justified in promptly beginning a program of extensive buying.

Representatives of manufacturers of iron and steel from all parts of the country, at a meeting at the Waldorf on Mar. 6, voted to coöperate with The Industrial Board of the Department of Commerce in its efforts to stabilize business conditions. Judge Elbelt H. Gary, chairman of the Board of the United States Steel Corpn., who presided, appointed the following committee to confer with the Industrial Board: Judge Elbert H. Gary, James A. Farrell, Charles M. Schwab, John A. Topping, Alva C. Dinkey, L. E. Block, James A. Burden, Eugene G. Grace, C. H. McCullough, Jr., H. C. Dalton, A. F. Huston, James A. Campbell, and Willis L. King. This, with only a few exceptions, comprises the personnel of the Special Committee of the American Iron and Steel Institute which assisted the Government in its operations in the war period.

SULFURIC ACID

In 1914, the United States produced 4,200,000 tons of sulfuric acid of 50° Baume. By 1917, this had increased to 8,300,000 tons and if the war had lasted 4 or 5 months longer we should have been making it at the rate of 9,600,000 tons annually. The rated capacity of works outside of those owned by the Government, which are now closing down, is 6,200,000 tons. The opinion is expressed that the present industries of peace will absorb 1,500,000 tons more than in 1914.

EXPLORATION OF MINERAL RESOURCES OF THE CENTRAL ANDES

Johns Hopkins University is planning to send, during April, a party to study the geology and mineral resources of the Central Andes in Bolivia and Peru. The expedition will be in charge of Edward W. Berry, professor of paleontology, and Joseph T. Singewald, Jr., professor of economic geology. The plans include a visit to the cinnabar mines of Huancavelica, Peru, and the silver and tin mining districts of Bolivia. An effort will also be made to obtain new light on the recent great changes of level of the high plateau of Bolivia.

During the week of Feb. 17, when the New York meeting was held, forty different meetings were held in the Engineering Societies' building.

PERSONAL

The following is an incomplete list of members and guests who called at Institute headquarters during the period Feb. 10, 1919, to Mar. 10, 1919.

R. H. Allport, Cleveland, Ohio.
I. H. Bergstein, New York.
Capt. R. S. Burdette, San Antonio, Tex.
William R. Chedsey, State College, Pa.
L. R. Clapp, Philadelphia, Pa.
J. Murray Clark.
E. H. Claussen, San Francisco, Calif.
George E. Collins, Denver, Colo.
George L. Collord, Sharpsville, Pa.
William M. Corse, Mansfield, Ohio.
Frank R. Crampton, Los Angeles, Calif.
Capt. E. O. Daue.
A. E. Eddy, Butte, Mont.
N. H. Emmons, 2d, Lynchburg, Va.
E. W. Engelmann, Hayden, Ariz.
F. A. Fahrenwald, Cleveland, Ohio.
O. S. Finnie, Ottawa.
John T. Fuller, Honesdale, Pa.
Major C. C. Griggs, Eureka, Utah.
H. F. E. Gamm, Rutherford, N. J.
A. W. Hackwood, Butte, Mont.
C. L. Horne, Roanoke, Va.
B. B. Hood, Chrome, N. J.
R. E. Hore, Toronto, Ont.
Ross B. Hoffmann, Oakland, Calif.
G. A. Joslin, Salt Lake City, Utah.
John Johnston, Washington, D. C.
Paul S. King, Wilmington, Del.
E. William Kohl, Jr., Philadelphia, Pa.
W. H. Landers, San Francisco, Calif.
R. R. Landon, Philippine Islands.
Alfred O. Law, Cambridge, Mass.
James M. Little, Towanda, Pa.
F. E. Marcy, Salt Lake City, Utah.
H. F. Nash, Bartlesville, Okla.
L. S. Panyity, Columbus, Ohio.
W. C. Ralston, Reno, Nev.
T. A. Rickard, San Francisco, Calif.
W. A. Rigby, Mt. Vernon, Iowa.
H. H. Rowatt, Ottawa.
P. H. Royster, Pittsburgh, Pa.
Alan B. Sanger, Dorchester, Mass.
J. S. Shaw, Pittsburgh, Pa.
S. B. Shutts, Lynchburg, Va.
Henry B. Smith, New Britain, Conn.
W. C. Smith, Roselle, N. J.
Harry M. Spoor.
D. M. Stackhouse, Johnstown, Pa.
F. D. Stay, Cleveland, Ohio.
D. B. Sterrett, St. Cyr, Que.
R. H. Thayer, Yonkers, N. Y.
Kirby Thomas, New York.
Henry Traphagen, Toledo, Ohio.
H. D. Trounce, San Diego, Calif.
Henry J. Volkin, Ossining, N. Y.
A. T. Ward, Bellefonte, Pa.
Major L. W. Wickes.
Horace V. Winchell, Minneapolis, Minn.
Fred L. Wolf, Mansfield, Ohio.

J. Carson Adkerson, of the Stockwood Realty Corpn., Inc., of Woodstock, Va., writes that they are discontinuing their operations in Virginia on account of the conditions in the manganese market following the end of the war.

Claude E. Amidon, who has been serving the United States at the Astoria Heat, Light & Power Co., Chemical Warfare Section, has removed to 40 Block F, Pueblo, Colo.

L. K. Armstrong, secretary-treasurer of Columbia Section, has been chosen president of the Spokane Engineering and Technical Association.

Percy E. Barbour, who has been honorably discharged from service as Captain of Engineers, U. S. A., has resigned the Deputyship of the New York State Troopers, Department of State Police, from which he had a leave of absence from the Governor, and has accepted the appointment of Assistant Secretary of the Institute.

Ralph E. Barker, recently with the Garfield Smelting & Refining Co., of Garfield, Utah, has accepted a position at the Tacoma Smelter, Tacoma, Wash.

H. L. Batten is with the Consolidated Mining & Smelting Co. of Canada at Rossland, B. C., Can.

D. D. Berolzheimer is now with the Chemical Catalog Co., 17 Madison Ave., New York, in the capacity of assistant technical editor.

Oliver U. Bradley is located at Muskogee, Okla., being U. S. Oil and Gas Inspector for the Department of the Interior with offices in the Federal building.

Jerome R. Buchanan, Captain of Engineers, recently discharged, is now manager of the Homestead-Iron Dyke Mines Co., Homestead, Ore.

F. E. Butcher is vice-president and general manager of the Dominion Co. at Danville, Ill.

Federico Garcia Caceras has closed his connections with Negociacion Minera E. E. Fernandini, Cerro de Pasco, Peru, and has accepted the position of metallurgical engineer for Compania Gallofa-Consolidada de Colque-Chaca, Bolivia, S. A.

Sgt. **Norman L. Calder** of the Royal Engineers expects to leave soon for Johannesburg, Transvaal, So. Africa.

S. D. Callaway has formed a partnership with J. E. Davis, civil engineer; they are doing business under the name of the Chotaw Engineering Co., Patrick Bldg., Poteau, Okla.

F. D. Chase has removed from Monterrey, Mex., to Dedham, Mass.

William C. Coffin, lately with the Jones & Laughlin Steel Co., is now vice-president of the Blaw-Knox Co. of Pittsburgh.

Edward H. Coxe has resigned his position with the United Coal Corpn., and is now general manager of the Snowden Coke Co. at Braznell, Pa.

Assistant Secretary of War **Benedict Crowell** and a party of friends recently made the trip from Washington, D. C., to New York by airplane. One of the airplanes at that time made the trip, a distance of 232 mi., in 1 hr. 41 min.

Walter S. Dickson has accepted the position of Engineer of Public Works with the Reconstruction Commission of the State of New York with offices at the Hall of Records, New York City.

Charles W. DeWitt resigned his position as mine superintendent with the Chiksan Mining Co. and has accepted a position with the United States Government in Siberia; he is on his way to Omsk for instructions.

H. C. Dudley recently returned from France, where he was a Captain in the Department of the Chief Engineer of the First Army. Before being transferred to the first Army in September, at the start of the San Mihiel offensive, he was with the 36th Engineers in central France. Mr. Dudley has reopened his offices at 704 Lonsdale Building, Duluth, Minn.

Edward H. Emerson, mining engineer, announces his recent connection with the General Chemical Co., 25 Broad St., New York.

Carroll R. Forbes, having received his discharge from military duty, has resumed his work at the School of Mines of the University of Missouri, Rolla, Mo.

Paul R. Forbes has located at 712 Prospect Avenue, El Paso, Tex., having resigned his position with Shewan-Tomes & Co. of New York.

R. W. French has removed from Ingot, Calif., to Department of La Union, San Sebastian, Salvador, C. A.

Paul W. Gaebelein, mining and metallurgical engineer, and recently First Lieutenant, Ordnance Reserve Corps, has opened offices at 17 W. Nintah St., Colorado Springs, Colo.

F. L. Gilman, who resigned his position as works manager of the National Conduit & Cable Co. last November, is now European general superintendent for the Western Electric Co., and has charge of that company's manufacturing plants in England and on the Continent.

Stanley N. Graham of Cobalt, Ont., lately at the O'Brien mine, is now at 136 Bagot St., Kingston, Ont., Can.

Samuel M. Greenidge is at present with the Leadville Mining Co. at Courtland, Ariz.

Mortimer L. Hall is research chemist in the electro-zinc plant of the U. S. Smelting & Refining Co., of Kennett, Shasta Co., Calif.

K. F. Hansen is employed by the American Zinc & Chemical Co. at Langeloth, Pa.

William Holzhauer is in the metallurgical department of the Aluminum Castings Co., at Cleveland, Ohio.

Herbert Hoover, the American Food Administrator, lately appointed director general of the Interallied Relief Organization, has announced that he and most of his associates will have to leave the Government service about July 1 in order to attend to their personal interests.

David L. C. Hover, recently at Chihuahua, Mex., has removed to Monterrey, N. L., Mexico, where he is in the employ of the American Smelting & Refining Co., in the Monterrey plant.

J. F. Inglis is with the Harmony Mines Co. of Baker, Ore.

David D. Irwin has taken a position in the office of the president of the Phelps-Dodge Corpn. at Douglas, Ariz.

F. M. Jardine, having been honorably discharged from the army, is at the Butte & Superior Mining Co., Butte, Mont.

Hennen Jennings has resumed his duties in Washington.

R. A. Josey has removed from Tulsa, Okla.; his new address is Box 698, Yale, Okla.

Amor F. Keene has changed his office address from 1 London Wall Bldg., London, Eng., to room 1100, 42 Broadway, New York.

Herbert B. Kroeger has resigned his position with the Cauto Mining Co., of Cuba. His present address is R. F. D. 30, Stamford, Conn.

S. S. Lang is superintendent of the Colby & Ironton mines at Bessemer, Mich.

Verner T. Lawshe, upon returning to civil life after sevice with the 311th Engineers, has resumed his engineering practice as chemical engineer for the Wyoming Chemical Co., of Wilkes-Barre, Pa.

Leon R. Long announces a change in position to the Cerro de Pasco Copper Corpn. at Cerro de Pasco, Peru.

George V. Luerssen, lately lieutenant with the Ordnance Department, has accepted a position in the metallurgical department of the Carpenter Steel Co. of Reading, Pa.

E. P. McCrorken having received his discharge from the Bureau of Steam Engineering, Naval Aviation, has resumed his duties with the *Engineering and Mining Journal.*

Robert Macfee in an interesting letter tells of his experiences as follows: "I have just recently been liberated by the Turks in whose hands I was a prisoner for over 8 mo. and am at present attached to the staff of the British Army in Baker, Caucasus, but expect soon to return to Manchester, Eng."

John deN. Macomb, Captain of Engineers, A. E. F., upon returning to civil life accepted the position of office engineer with the Atchison, Topeka & Santa Fe Ry., with offices at 1033 Railway Exchange Bldg., Chicago, Ill.

William S. Mann is chief engineer, Missabe Range Dept., Republic Iron & Steel Co., Gilbert, Minn.

Stuart B. Marshall, consulting engineer and metallurgist, is removing his offices to the Commercial & National Bank, G and 14th Sts., N. W., Washington, D. C.

William E. Merritt, recently with the Tennessee Chemical Co., has taken a position with the Calco Chemical Co. at Bound Brook, N. J.

J. A. Meyerovitch is vice-president of the Youroveta Home & Foreign Trade Co., with offices at 165 Broadway, New York.

Walter B. Miller, Captain of Engineers, having received his discharge, is general manager of the Kentucky King Coal Co., at Wallins Creek, Ky.

J. Macdonald Mitchell has taken a position at La Paz, Bolivia, with the W. R. Grace Co.

Harold A. Morrison is sales engineer for the Oliver Continuous Filter Co., 229 Madison Av., New York.

Chester Naramore resigned his position as chief petroleum geologist with the Bureau of Mines on Feb. 1, 1919, to accept a position with the Union Petroleum Co., Philadelphia, Pa.

L. F. Paddison is now with the Sunnyside Mining & Milling Co. of Eureka, Colo., having left the employ of the U. S. Smelting, Refining, & Mining Co., of San Francisco, Calif.

F. D. Pagliuchi, mining engineer, has opened offices at 1130 Title Insurance Bldg., Los Angles, Calif.

Edwin H. Peirce has accepted the position of superintendent of the American Steel & Wire Co., at New Haven, Conn.

Charles Y. Pfoutz has been transferred from the Arthur plant to the Magna plant of the Utah Copper Co., Magna, Utah.

Albert E. Pillow is engineer, Société Belge Industrielle et Minière de Katanga, Elisabethville, Katanga, Congo Belge, So. Africa.

H. Robinson Plate has removed from New York, to Sheepranch, Calif.

E. T. Plumb, recently of Brooklyn, N. Y., is now with the Cumberland Pipe Line Co., Winchester, Ky.

K. Pommerantz has resigned his position with the South American Metal Co. (Fundicion de Guayacan) and has opened offices at Casilla 489, Santiago de Chile, Chile, S. A., as an independent consulting engineer.

W. C. Ralston has moved from Reno, Nev., to 25 Broad St., New York.

Bert A. Reber, having completed his work at Absarokee, the hydroelectric plant being placed in operation, has accepted a position with the Cascade Silver Mine & Mill Co. as mining engineer and in flotation.

R. S. Rhoades announces the opening of the firm of Douglas & Rhoades at Dan Waggoner Bldg., Ft. Worth, Tex.

Edwin R. Richards, formerly vice-president of the Childers Leasing Co., has taken offices at 526 Remington Av., Salt Lake City, Utah.

Jasper T. Robertson has removed from Chicago, Ill., to Hobart Bldg., San Francisco, Calif.

A. Edmond Robitaille, petroleum geologist, has become associated with Dorsey Hager in the American Exchange National Bank Bldg., Dallas, Tex.

Harry M. Rockwell has accepted a position with the International Smelting Co., at Tooele, Utah.

Max Roesler announces his connection with the U. S. Geological Survey, at Washington, D. C.

Girard B. Rosenblatt has taken a position with the Westinghouse Elec. & Mfg. Co., Salt Lake City, Utah.; he is in charge of the mining and metallurgical work in the West.

Capt. R. W. Rusterholz has been transferred from the Air Service, A. E. F., to the Engineering Detachment of the American Peace Commission, where his work will be the appraisal of all damages in the devastated districts of all countries.

Richard M. Sanchez has taken a position with the Alvarado Mining & Milling Co. at Parral, Chihuahua, Mex.

Prof. Albert Sauveur, of the metallurgical department of Harvard University, has just returned to Cambridge, Mass., from France, where he has been engaged in war work the past year. While in Paris, Professor Sauveur was in charge of the section of metallurgy in the technical division of the United States air service, the purpose of which was to solve metallurgical problems connected with aviation motors.

L. R. Scheurer, professor of mining engineering, has accepted a position with the North Georgia Agricultural College, having resigned at the Missouri School of Mines.

D. R. Semmes, formerly a professor of geology at the Texas A. & M. College, has opened an office at 47 Petroleum Bldg., Fort Worth, Tex., for general consulting work in the North Texas region.

Homer K. Sherry has changed his address from the Wisconsin Zinc Co., to Asbestos, Que., Can.

Ralph W. Shumway is mine superintendent with the Manufacturers Coal & Coke Co. at Hellier, Ky.

W. A. Siebenthal, having been in charge of operations with the Western Ore & Mining Co. since the summer of 1917, has resumed his former position of mining engineer with the Penn Iron Mining Co., at Vulcan, Mich., the Western Ore & Mining Co. having closed its operations on manganese ores.

Captain John G. Smyth, of Berkeley, Calif., is at present manager of the Elkhorn Division of the Consolidated Coal Co., of Jenkins, Ky.

E. K. Soper is now geologist with the Trinidad Petroleum Development Co., P. O. Box 175, Port of Spain, Trinidad, B. W. I.

Paul Stein is at present with the American Smelting & Refining Co. at the Hayden plant, Hayden, Ariz.

Leighton Stewart, who was overseas as a Lieutenant in the Canadian Engineers, has re-opened his office at 42 Broadway, New York.

Percy W. Thompson is with the Richmond Petroleum Co. at Meeker, Colo.

Warren D. Thompson, mining engineer, is at present in Chuquicamata, Chile, S. A., with the Chile Exploration Co.

Jon A. Udden is now chief geologist, Sinclair Gulf Oil Co., Burk Burnett Bldg., Ft. Worth, Tex.

Frederick H. Vahrenkamp, of the firm of Vahrenkamp & Elder, having been absent from the United States for over a year, is now definitely located again at Coarsegold, Madera Co., Calif.

C. T. Van Winkle, mining and metallurgical engineer, is now situated in Salt Lake City, Utah, with offices in the Dooly Block.

Frederick A. Voorhees has changed his address from Daggett, Calif., to Bacis Gold & Silver Mining Co., Ltd., Mazatlan, Sinaloa, Mex. He and William Brandt are returning to the property of the Bacis Co., in the State of Durango, in an effort to rehabilitate and operate the mill and mine after 6 years shut-down.

Charles W. Weston is operating manager of the Market St. Elevated Railway Co., 69th & Market Sts., Upper Darby, Delaware Co., Pa.

Joseph L. White has accepted the position of superintendent of the Bluebell mine, at Mayer, Ariz.

H. E. Whitfield is at the University of Western Australia, Perth, Western Australia.

W. deBurgh Whyte, Deputy Director of the Production Department of the British War Mission in the United States has been made an officer of the Order of the British Empire by the King for services rendered during the war.

Garratt S. Wilkin is in Salt Lake City, Utah, as mine manager of the Moscow Mining & Milling Co.

F. M. Wolverton has received his discharge from military service and is now a student at the University of Wisconsin, Madison, Wis.

Wallace G. Woolf has removed from Silver City, Utah, and is with the Bunker Hill & Sullivan Mining & Concentrating Co., at Kellogg, Ida.

ENGINEERS AVAILABLE

(Under this heading will be published notes sent to the Secretary of the Institute by members or other persons introduced by members.)

No. 526.—At liberty about Mar. 1, 1919. Just returned from France, a Captain of Engineers. Member A. I. M. E., A. I. E. E., 35 years old, technical education. Last six years of civil life as electrical engineer, master mechanic and superintendent of construction with large mining company. Salary expected, $3600 per year.

No. 535.—Member, mining engineer, technical graduate, age 34 years, experience as engineer for coal companies. Three and one-half years with one company and five years with another. Have good recommendations. Recently honorably discharged, First Lieutenant, U. S. Army. Desires position, preferably in West. Salary last received, $175 per month.

No. 555.—Metallurgical engineer having 18 years' experience in positions from chemist to manager, specializing in the smelting of copper, gold and silver ores, and now returning to the U. S. Available about May 15.

No. 556.—Manager or superintendent, member, technical graduate, age 44, married, desires position. Good references, 18 years' experience in positions of responsibility and administration. Familiar with development, mining, milling, operation, construction and management. Available on short notice.

No. 557.—Member, technical education, married, age 30. Five years' experience in construction work, four years superintendent of mining and milling operations. Looking for wider experience. Free Apr. 1.

No. 558.—Member, age 29, mining geologist with thorough scholastic and practical training. Best of references. Supervision of underground metal-mining development. Student of administration and capable as engineer. Open for engagement in any English-speaking country at salary equivalent to $3500.

No. 559.—Metallographist or laboratory metallurgist, member,

technical graduate, 28, single. Worked one year with Illinois Steel Co., Gary Works, but will be released before Apr. 1. Present salary $140. Experienced photomicrographist and a good photographer. Highest credentials.

No. 560.—Columbia E. M., 1912, thirty, married, experienced in recovery work after fires and explosions in metal and coal mines and in training men in safety, rescue and first-aid work. Has been engineer, superintendent and purchasing agent. Formerly in service of U. S. Bureau of Mines. Competent to inaugurate and conduct safety, efficiency and welfare campaign.

No. 561.—Member, married, age 42 years, 20 years' experience both mining and metallurgy in Western States, Mexico and Central America. Speaks French and Spanish, late superintendent large low-grade gold property California. Open for engagement as manager or superintendent, preferably in South America.

No. 562.—Metallurgist, member, technical graduate, age 30, married. Four years' experience in steel and ferro-alloy research. Desires better opportunity for advancement.

No. 563.—Member, age 38, desires position as construction engineer with some copper company. Ten years' experience in Utah and Arizona on design, construction and operation of copper smelting and leaching plants. Least salary considered, $300.

No. 564.—Wanted: Position by an experienced mine and mill foreman. Thoroughly efficient in amalgamation and concentration of gold and silver ores. Also, many years as mine foreman in South America, South Africa, Nevada and California. Experienced.

No. 565.—Graduate mining engineer, member, married, with nine years' practical experience from mucker to superintendent, desires position as superintendent or manager of mine. Available upon short notice.

No. 566.—Member, metallurgical chemist and engineer with wide experience in Russia (Ural Mts., Siberia and Caucasus) will be free end of April. Expert in concentration (table and flotation) of lead-zinc and copper ores. Large practice in smelting of copper ores in blast furnaces and refining of copper. Experienced assayer and ore tester. Speaks Russian and knows his way about the country.

No. 567.—Member, age 28, married, technical training, experienced in both practical and technical flotation work. Desires position as a flotation testing engineer, foreman or superintendent. Would be willing to start with reasonably low salary, providing there would be a chance for advancement. Available at once.

No. 568.—Member, mechanical and electrical engineer, age 34, experience in directing design and construction of power, mining and smelting plants in the Southwest and Mexico. Available Apr. 1, salary $300 per month.

No. 569.—Consulting geologist, established at Fort Worth, Tex., desires to represent reputable companies and investors in the Texas oil fields. Three years' experience in the oil fields of this region. Best of references offered.

No. 570.—Member, graduate engineer and geologist, married, age 31 years, open for immediate engagement. Eight years' experience as engineer, geologist, foreman and superintendent of coal, iron and copper properties. Speaks Spanish. Best of references.

No. 571.—Coal-mining engineer and superintendent, member, married, age 35, desires position as engineer or superintendent, or combination of the two, with a company offering chance for advancement. Has had 13 years' experience in coal mining, last five years as engineer and superintendent in charge of property producing 850,000 tons annually. Minimum salary, $350.

No. 572.—Metallurgical and chemical engineer wishes to become affiliated with a first class university in the department of metallurgy. Has had seven years' teaching experience at universities and five years in practice. Has the following degrees: B. S. Chem., M. S. Met., and P. D. Met. First class references. Would also consider good opening in practice.

No. 573.—Engineering executive, returning to the U. S. from France about May 1, desires an opportunity to secure a permanent position with prospects of advancement. Graduate civil engineer. Member, American Institute Mining Engineers, American Society of Mechanical Engineers, and Assoc. Member American Society of Civil Engineers. Experience: Railway engineering, 5 years; management, 8 years; military engineering, 2 years. Entered Army as Captain Engineers, May, 1917, promoted to Lt. Colonel, Engineers, January, 1918. Age 35.

No. 574.—Member, 36 years old, married, 16 years' practical experience, metal and coal mining and oil-field construction and pipe line. Will gladly consider foreign location and am equipped for such a trip, being familiar with shaft sinking, timbering, mine surveying, developing new properties, boilers, engines, pumps and machinery, both installing and operating.

No. 575.—Graduate mining engineer, member, single, 25 years old. Recently discharged from service as 1st Lieutenant, F. A. Go anywhere at once. Best references.

POSITIONS VACANT

Assistant Professor of Mining Engineering.—Mining engineer to teach mine surveying, mine mapping, assaying, etc., but not metallurgy. Location, Ohio. Salary, $1800 per annum. No. 379.

Metallurgist.—Experienced metallurgist capable of running 25-ton blast lead furnace. Man who knows the country and speaks Spanish desired. You may know that this state is in peaceful conditions and that even during the worst time of the revolution there were several mining concerns never idle. Besides, its resources are wonderful, and once a man gets started, he will find many possibilities. Notwithstanding that Sinaloa is a mining state, our smelter will be the only lead smelter on this coast. Location, Culiscan, Sin., Mexico. No. 381.

Quarry Superintendent.—Engineer experienced in limestone quarry work for position as superintendent; must be capable of producing results; must increase output of quarries from 4 to 12 cars per day. Young man with abundant energy is desired. Permanent position, chance to grow up with the company. Location, New Jersey. Salary depends upon the man. No. 382.

Rubber Chemist.—Man experienced in the making of compounds for insulating wires; must be capable of developing high-grade compounds, 30 per cent. and 40 per cent. Para, to meet specifications of the Railway Signal Association, U. S. Signal Corps, U. S. Navy, etc. Will be expected to check up manufacturing practices, ingredients used in compounding, reduce the cost of present code compounds, etc. Salary depends upon the man. No. 384.

Assistant Engineer.—Engineer experienced in construction and maintenance work; must have a working knowledge of Spanish, executive ability and be able to stand frontier life; should have had experience in Spanish America. Location, Cuba. Salary, $250 per month. No. 385.

Head for Metallurgical Laboratory.—Research engineer, experienced in ferrous and non-ferrous laboratory work. Must be familiar with plant process and manufacturing operations, among other things, duties will consist of collecting empirical data to be used in the drafting of specifications. Location, Ohio. Salary depends upon the man. No. 386.

Sales Engineer.—Man with knowledge of materials and uses to go into undeveloped territory to sell farming implements, power-plant equipment, hardware, etc., and represent company among managers; speaking knowledge of Spanish required. Location, Argentine Republic. Salary about $5000. No. 387.

Production Manager.—Man with considerable experience in the manufacture of small hand-power grinding machines, with a thorough knowledge of the coördination of production elements such as making and buying of stock, stock on hand and stock necessary to fill orders properly, as nearly as possible, and save accumulation of unnecessary stock. Must also know how to handle men harmoniously; in other words, he should be a man who can grasp the problem of production in all its details and produce the goods, not simply make promises thereof. No. 388.

Mine Superintendent.—Mining engineer experienced in handling iron ore and in underground and open-cut work for the position of mine superintendent; graduate engineer preferred; unmarried, under 33 years old. Location, Pennsylvania. Salary depends upon the man. No. 389.

Assistant Professor.—Man to take charge of coal-washing and ore-dressing laboratory at a mining school in the Middle West. No. 390.

Research Work.—A man for research work in connection with coal mining and preparation for a mining school. No. 391.

Mining Engineers and Assistant Engineers.—Services of a number of men required for examination work to check up claims for the Government. Should be men of standing and judgment as well as men of experience. Those having experience in manganese, chrome, pyrite and tungsten especially desired. Salary for mining engineers, $3600 to $4800; salary for Assistants, $1800 to $3000 per annum basis, depending upon the man. Work to last for several months. No. 392.

Resident Manager for position with iron and steel company in Mexico. Must be familiar with operation, ore mining and smelting. Nothing less than a $15,000 man need apply. No. 395.

FORTHCOMING MEETINGS OF SOCIETIES

Organization	Place	Date
		1919
American Electrochemical Society	New York, N. Y.	Apr. 3–5
American Chemical Society	Buffalo, N. Y.	Apr. 8–11
National Foreign Trade Council	Chicago, Ill.	Apr. 24–26
American Iron and Steel Institute	New York, N. Y.	May
American Institute of Electrical Engineers	Lake Placid, N. Y.	June 23–27
American Society for Testing Materials	Atlantic City, N. J.	June 24–27
American Railway Bridge and Building Association	Cleveland, O.	Oct. 21–23

BIOGRAPHICAL NOTICES

HUBERT INGERSOLL ELLIS

Hubert Ingersoll Ellis, who met accidental death on Jan. 6, 1919, in eastern Washington, had already advanced far in the profession of mining engineering and gave promise of a brilliant future. He was born on the Washington coast in June, 1889, and had his preparatory schooling at Menlo, Wash. In 1905, he entered the College of Mines of the University of Washington, and at once made a high record of scholarship. After completing 3 years of his technical course, he went to the interior of Alaska, where he spent 4 years in mining. During this time he was field correspondent for technical magazines and wrote several important articles. In 1915, Ellis completed his senior year in the College of Mines; his graduation thesis was a comprehensive paper on mining methods at Fairbanks, Alaska, which was published as a series of articles in the *Engineering and Mining Journal.* On July 14, 1915, he entered the employ of the Bunker Hill & Sullivan Mining & Concentrating Co., Kellogg, Ida., as an underground miner, and was soon promoted to the position of operative on experimental metallurgy and later chemist in the same work. Later, he did exhaustive work on flotation with particular attention to the use of various addition agents. For the past 2½ years, his work was largely in the field, examining mining prospects and directing work of investigation, during which time, while located at Sumter Valley, Ore., in 1916, he was elected to membership in the American Institute of Mining and Metallurgical Engineers. During the same year, he was married to Miss Grace Wells, of Arkadelphia, Ark., and besides his widow leaves a young son.

In Hubert I. Ellis, there was found the rare combination of executive, administrative, and business ability, together with a temperament exceptionally well adapted and trained for research work and for the careful and exhaustive examination of engineering problems, both practical and academic. These qualities were in addition to a splendid physique and a personality that made him highly successful in the handling of subordinates and in his contact with his associates and the public.

FRANK G. D. SMITH

Frank G. D. Smith died Jan. 20, after a short illness of influenza that resulted in a complication of diseases. Mr. Smith was employed for the past 3 years as superintendent of the silver refinery, at the East Chicago

plant, of the United States Metals Refining Co. Before this, he was manager of the Santa Domingo Silver Mining Co., at the famous old Batopilas camp, in Chihuahua, Mex. It required great fearlessness to conduct the operations during the revolutionary days in this very inaccessible place, but he fulfilled the responsibilities entrusted to him and kept up production until American intervention made work impossible.

Frank Smith was a close student and exceedingly well posted on mining and metallurgy. He was very unassuming, and the only evidence of his rare ability was that he solved the problems that were presented in a thoroughgoing way. The loss of a true friend, who practised the golden rule in all of his dealings, will be felt by many engineers scattered throughout the United States and Mexico

ALLAN FRASER McCORMICK

Alan Fraser McCormick died of pneumonia at El Paso, Tex., on Dec. 23, 1918. Mr. McCormick was born in the Province of Ontario, Can., 43 years ago, and at the time of his death was assistant superintendent of the El Paso Smelting Works. He began his career in the smelting business about 20 years ago at the smeltery at Trail, B. C. From Trail, he went with the Granby Consolidated Copper Co., and subsequently was connected with mining companies in Montana. When the Nevada Consolidated Copper Co.'s smeltery was blown in, Mr. McCormick was assistant to Walter G. Perkins, who was in charge of smelting operations. In 1911, he went to the El Paso Smelting Works as assistant superintendent in charge of copper reverberatory smelting and converting operations, where he remained until the time of his death.

SEELY B. PATTERSON

Seely B. Patterson, one of the early iron masters of New Jersey and Pennsylvania and for many years a member of the American Institute of Mining and Metallurgical Engineers, died at the Women's Homeopathic Hospital, Philadelphia, on Jan. 22, and was buried in Allentown, Pa., his recent home. Born on Henry St., New York City, June 2, 1845, he was educated in the New York public schools and the Free Academy, now the College of the City of New York. His father, Henry A. Patterson, was a founder of the firm of Patterson Bros., 27 Park Row, New York.

Mr. Patterson, upon graduation, in 1864, from the Free Academy, went with the Andover Iron Co. at Philipsburg, N. J., and shortly after became superintendent of the Philipsburg Stove Works. Later he spent a year in northern Michigan managing a charcoal blast furnace on Pine Lake, and then went to West Virgina to manage the coal mines and blast furnace at Quinnimont on the New River. In 1886, he was called to Hibernia, N. J., to manage the mines of the Andover Iron Co.; in 1894, however, he was placed in charge of the entire property of the Andover Iron Co., and moved to Philipsburg, N. J., where the blast furnaces were located. When these properties were sold to Joseph Wharton, in 1902, Mr. Patterson became assistant to the president of the Empire Steel & Iron Co., Catasauqua, Pa., when he paid especial attention to the development of new orebodies at Mt. Hope and the installation of a central power plant at Oxford. In 1904, he became manager of the Robesonia

Iron Co., Ltd., mines at Cornwall, Pa., and blast furnace at Robesonia, Pa., where he remained until his retirement from business in 1916.

He is survived by his widow, Mrs. Josephine Meeker Patterson; one daughter, Mrs. G. W. Hunsicker, of Allentown, Pa., and three sons, all of whom were in the U. S. Service: Lt. Commander H. R. Patterson, *U. S. S. Arizona;* Lt. Seely B. Patterson, Jr., Engineers, U. S. A.; and Ensign George M. Patterson, *U. S. S. Lake Dancy.* He is also survived by his mother, who is 95 years old; by three sisters, Miss Annie C. Patterson, Mrs. Daniel K. Hall, and Mrs. Frederick Horn, of Paris, France, now employed by the French Government in war welfare work; and by two brothers, Charles Patterson, of New Orleans, and Turner Patterson, of San Diego, Calif.

GEORGE E. WEBBER, JR.

George E. Webber, Jr., the son of George E. Webber, late general manager of the Rand Mines Ltd. group of mines in Johannesburg, South Africa, was born near Lead City, S. D., Mar. 6, 1886. He died in San Francisco, Calif., Oct. 26, 1918, from an attack of influenza and pneumonia.

Most of his education was acquired in California at the Belmont School and the State University. Completing the course in mining engineering in the latter part of 1908, he entered the service of the Crown Mines Ltd., of Johannesburg, South Africa, where he remained 3 years, filling successfully the positions of sampler, shift boss, mine surveyor, and mine captain. Becoming discontented with South Africa after his parents left there, he returned to California early in 1912, and shortly afterward accepted a position as mine surveyor at the Jualina mine in Alaska, where he continued until the closing down of the property in 1914. He then accepted the position of assayer at the San Salvador mine (Butters), San Salvador, but sickness forced him to resign in a few months. In 1915, he became safety engineer at the Dome mine in Ontario, Can., which position he held until 1917, when he became shift boss at the Braden copper mine, Chile. He left that company in 1918 to return to California to join the army and received his appointment as lieutenant in the 403d Engineers, training at Ft. Douglas, Utah. He never took up his military duties, however, as he died a few days after receiving his appointment.

CHANGES IN ENTRANCE CREDITS AT PRINCETON AND YALE

At Princeton University a knowledge of Greek will no longer be an entrance requirement. A knowledge of Latin will be required of candidates for the Bachelor of Arts degree, but men entering courses leading to the Bachelor of Science degree may offer modern languages and mathematics instead.

At Yale University also Latin is to be transferred from the group of required studies for admission to college and the group of elective studies. Courses in American history and government will be required of all undergraduates. In addition, greater attention is to be paid to matters connected with student extra curriculum activities, morale, and discipline.

LIBRARY

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS
AMERICAN SOCIETY OF CIVIL ENGINEERS
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
AMERICAN SOCIETY OF MECHANICAL ENGINEERS
UNITED ENGINEERING SOCIETY

The Library of the above-named Societies is open from 9 A. M. to 10 P. M. except on holidays. It contains about 70,000 volumes and 90,000 pamphlets, including sets of technical periodicals and publications of scientific and technical societies.

Members of the Institute, with few exceptions are forced to spend a portion of their time in localities isolated from sources of information. To these the Library, through its Library Service Bureau, can render valuable service through correspondence; letters requesting information will receive especial attention. The Library is prepared to furnish references and photographic copies of articles on mining and metallurgical subjects; to determine the existence of mining maps, and to furnish general information on the geology and mineral resources of all countries.

All communications should be made as definite as possible so that the information received may be what is desired and not include collateral matter which may not be of interest. The time spent in searching for such collateral matter will be saved, and the information will be sent more promptly and in more usable shape.

HARRISON W. CRAVER, *Director*.

Library Accessions

BARITE DEPOSITS OF MISSOURI AND THE GEOLOGY OF THE BARITE DISTRICT. By William Arthur Tarr. Univ. of Missouri Studies, vol. 3, No. 1. Science series. (Gift of author.)

BOILERS AND FURNACES CONSIDERED IN THEIR RELATIONS TO STEAM ENGINEERING. By William M. Barr. Philadelphia, 1899. (Gift of American Society of Mechanical Engineers.)

LE COMMERCE FRANCO-AMÉRICAIN. Rapport de la Commission Industrielle Américaine en France a l'Association des Manufacturiers Américains pour l'Exploration. Septembre–Octobre, 1916. Paris, 1917. (Gift of E. G. Spilsbury.)

LE DAUPHINÉ AU TRAVAIL. Textes in extenso des conférences pratiques organisées par la Chambre de Commerce de Grenoble, 1917. Grenoble, 1917. (Gift of E. G. Spilsbury.)

DEUXIÈME CONGRÈS DE LA HOUILLE BLANCHE, LYON, Septembre, 1914. Rapports qui devaient être présentés au Congrès. Paris, n. d. 2v. (Gift of E. G. Spilsbury.)

ETATS-UNIS ET DAUPHINÉ. Notice relative aux Produits du Dauphiné qui peuvent faire l'objet d'une exportation active vers les Etats-Unis. Chambre de Commerce de Grenoble. 1917. (Gift of E. G. Spilsbury.)

GUIDE INDUSTRIAL DU DAUPHINÉ, PUBLIÉ PAR LA CHAMBRE DE COMMERCE DE GRENOBLE. Houille Blanche. 1916.
Deuxième édition. Houille Blanche. 1917. (Gift of E. G. Spilsbury.)

HENDRICKS' COMMERCIAL REGISTER OF THE UNITED STATES FOR BUYERS AND SELLERS. New York. Copyright, 1918. (Gift of publishers.)

INDUSTRIAL ARTS INDEX. Annual cumulation. 6th, 1918.

Institution d'un Brevet d'Invention International. Examen des principes sur lesquels l'accord pourrait tout d'abord se faire entre les Alliés. Par Émile Barbet. Paris, 1916. (Gift of E. G. Spilsbury.)

International Catalogue of Scientific Literature. 14th annual issue, section B, Mechanics. Section C, Physics. 1917–18.

Krupp. A Century's History of the Krupp Works. 1812–1918. Translated from the commemorative volume edited by the Krupp Works. (Gift of the American Society of Mechanical Engineers.)

Making Walking Places Safe. 1918. The Menace of Slipping. 1918. Slipping and Tripping; the most Serious Public and Industrial Hazard. 1916. The Common Cause and Prevention of Industrial Casualty. 1917. By H. Weaver Mowery. (Gift of author.)

La Métallurgie en France et en Dauphiné. Son Passé; Son Avenir. Par Aimé Bouchayer. Grenoble, 1917. (Gift of E. G. Spilsbury.)

Minerals and Mining. Nova Scotia. By R. Drummond. Stellarton, N. S. 1918. (Gift of Hon. E. H. Armstrong.)

National Workmen's Compensation Service Bureau. A list of new books and articles received in the Library, September, 1918. (Gift of the Bureau.)

New Zealand. Mines statement for the year 1917. Wellington, 1918. State Coal mines (Reports on the working of) for the year ended 31st March, 1918. Wellington, 1918. (Gift of the Minister of Mines, New Zealand.)

Oklahoma Society of Engineers. Transactions. v. 2, 1916; v. 4, 1918. (Gift of Society.)

Present and Prospective Supply of Natural Gas Available in Pennsylvania. By Samuel S. Wyer. 1918. (Gift of author.)

Radium and Uranium; Their Ores and Occurrence in Nature. By R. A. F. Penrose, Jr. Albany, 1918. (Gift of author.)

Readers' Guide to Periodical Literature. Annual cumulation. 18th, 1918.

The Relative Corrosion of Cast Iron, Wrought Iron and Steel Pipe in House Drainage Systems. By William Paul Gerhard. (Gift of author.)

Representation in Industry. By John D. Rockefeller, Jr. 1918. (Gift of author.)

Steel Shipbuilders Handbook. By C. W. Cook. New York, 1918.

Tables of Useful Information. Joseph T. Ryerson & Son. 2d edition, 1918. (Gift of publishers.)

Tests of Moisture and Water Resistance of Various Coatings on Small Boat Construction. By Henry A. Gardner. (Gift of Institute of Industrial Research.)

Travaux Préparatoires du Congrès Général du Génie Civil, Session Nationale (Mars, 1918) 10 sections. Paris, 1918. (Gift of E. G. Spilsbury.)

Les Travaux Souterrains de Paris. Première partie, Les Eaux. Deuxième section, Les Eaux Nouvelles. Par M. Belgrand. Paris, 1882. 2 vol. (Gift of Edward Wegmann.)

Social Reconstruction. A general review of the problems and survey of remedies. 1919. (Gift of National Catholic War Council.)

Il Trattamento Termico Preliminare Degli Acciai Dolci e Semi-duri per Costruzioni Meccaniche. By Federico Giolitti. Milano, 1918. (Gift of author.)

Book Notices

Unless otherwise specified, books in this list have been presented by the publishers. The Institute does not assume responsibility for any statements made; these are taken from the preface or the text of the book, unless otherwise noted.

Fighting the Boche Underground. By H. D. Trounce. N. Y., Charles Scribner's Sons, 1918. 234 pp., 7 pl., 1 por., 1 diag., 8 × 5 in., ¼ cloth, $1.50. (Gift of author.)

Captain Trounce, an American mining engineer, enlisted in the Royal Engineers in 1915 and was transferred to the Engineer Reserve Corps of the American army in 1917. His book is a description of the underground fighting in which he participated in Flanders, at Arras, Vimy Ridge, and elsewhere.

Industry and Humanity. A Study in the Principles Underlying Industrial Reconstruction. By W. L. Mackenzie King. Boston and N. Y., Houghton Mifflin Co., 1918. 567 pp., 10 charts, 8 × 6 in., cloth, $3.

This volume, by the former Minister of Labor of Canada, is a statement of the underlying principles that are finding expression in the organization of industrial

society and which should obtain in all efforts at reconstruction. The book is based on the author's 20 years of personal contact with labor problems, supplemented by a study of the literature of the subject.

INSTINCTS IN INDUSTRY. A Study of Working-class Psychology. By Ordway Tead. Boston and N. Y., Houghton Mifflin Co., 1918. 222 pp., 8 × 5 in., cloth, $1.40.

With the idea of contributing to a better understanding of people in their capacity as manual workers, Mr. Tead has analyzed in turn the ten basic instincts on which our life and conduct rest, has shown how each affects the worker's relation to his job, and how each must be studied and used in the task of attaining sound relations between the employer and the employed.

THE INSTRUCTOR, THE MAN AND THE JOB. A Handbook for Instructors of Industrial and Vocational Subjects. By Charles R. Allen. Phila. and Lond., J. B. Lippincott Co. (copyright 1919), 373 pp., 8 × 5 in., cloth, $1.50.

The author, who has been Agent for Industrial Training for the Massachusetts Board of Education, and Superintendent of Instructor Training for the Emergency Fleet Corporation, gives the result of his experience in this volume, which is intended as a handbook for instructors in industrial plants and as instruction notes in training courses for instructors.

JOHNSON'S MATERIALS OF CONSTRUCTION. Rewritten by M. O. Withey and James Aston. Edited by F. E. Turneaure. 5th edition. N. Y., John Wiley & Sons, Inc.; Lond., Chapman & Hall, Ltd., 1919. 840 pp., illus., 1 pl., 1 por., tab., 9 × 6 in., cloth, $6.

As the progress of the past 20 years in the knowledge of the properties of materials made Prof. Johnson's book an inadequate account of the subject, it has been rewritten under the editorship of his successor at the University of Wisconsin. The authors have aimed to retain the broad scope of the original work as a statement of the essential information concerning the sources, manufacture or fabrication of the principal materials, their more important mechanical and physical properties, and the influences of various factors upon them, the causes of defects and variations, the methods of testing and their general uses. The arrangement of the book is new and some changes have been made in its scope. Obsolete matter has been eliminated and modern data substituted. The volume is intended to serve both as a textbook and as a work of reference.

PETROLEUM REFINING. By Andrew Campbell, with a foreword by Sir Boverton Redwood. Lond., Charles Griffin & Co., Ltd., 1918. 297 pp., 138 illus., 29 folding pl., 3 diag., 11 tab., 9 × 6 in., cloth, $8.50.

This volume, the only book in English devoted solely to the subject, describes the ordinary methods used to prepare marketable products from petroleum, except "cracking" methods. The work is based on extended practical experience, is well supplied with illustrations and drawings and includes a bibliography.

PHYSICS FOR TECHNICAL STUDENTS. SOUND, LIGHT, ELECTRICITY AND MAGNETISM. By William Ballantyne Anderson. 1st edition. N. Y., McGraw-Hill Book Co., Inc.; Lond., Hill Publishing Co., Ltd., 1919. 794 pp., 373 illus., 9 × 6 in., cloth, $3.

This book completes the author's textbook of physics, the first part of which has been published previously under the title: Mechanics and Sound. The writer has aimed to produce a college text especially suitable for students of agriculture and engineering, in which particular attention is directed to practical applications of the subject.

THOMAS' REGISTER OF AMERICAN MANUFACTURERS AND FIRST HANDS IN ALL LINES. N. Y., Thomas Publishing Co. (copyright 1919) 4200 pp., 12 × 10 in., cloth, $15.

The tenth edition of this well-known trade directory is dated "October" as usual, although corrections were made up to Dec. 20. The directory is divided into various lists, the chief one being a carefully classified list of manufacturers in all lines, subclassed geographically and provided with an extensive index to the classification. Other lists are of representative banks, boards of trade, chambers of commerce, etc., trade papers, leading trade names and an alphabetical list of manufacturers. The volume contains 4200 pages of information, conveniently arranged for quick consultation.

MEMBERSHIP

NEW MEMBERS

The following list comprises the names of those persons who became members during the period Feb. 10, 1919, to Mar. 10, 1919.

ALLEN, ROLLAND CRATEN......State Geol., Appraiser of Mines, Lansing, Mich.
ALTMAYER, MAURICE ERNEST, Ingenieur des Arts et Manufactures, 145 Rue de la Pompe, Paris, France.
AUSTIN, CHARLES L., Assayer, Highland Boy Mine, Utah Cons. Min. Co., Bingham Canyon, Utah.
BARTLETT, ARTHUR J., Chief Engr., Louisville Coal & Coke Co., Goodwill, W. Va.
BOIES, ORLOW W., Research Chem., Roessler & Hasslacher Chemical Co., 1632 Tenth St., Niagara Falls, N. Y.
BRAGG, G. A., Mgr., Experimental Copper Leaching Plant, Mellon Inst. of Industrial Research, Thompson, Nev.
BRUSCANTINI, GIOVANNI, Min. Engr., Gen'l Mgr., Sindicato Minero de Cuba, Box 370, Santiago, Cuba.
COLONY, R. J.........Instructor in Geol., Columbia University, New York, N. Y.
DAVENPORT, FRANK B., Cons. Engr., 806 Coal Exchange Bldg., Wilkes-Barre, Pa.
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ENGELHARDT, EDWARD A., Mgr., Surinaamsche Bauxite Mij, Paramaribo, Dutch Guiana, S. A.
ESCOVAR, A. JESÚS, Met., The Colombian Min. Co., Marmato, Caldas, Colombia, S. A.
FLEMING, ANDREW A., Chem. & Met., Dominion Arsenal, Quebec City, P. Q., Canada.
GOUVY, ALEXANDRE, Cons. Engr., Care Ste. de Montataire, 5 Rue St. Georges, Paris, France.
GRAHAM, HORACE REYNOLDS, Gen'l Min. Supt. & Welfare Mgr., Braden Copper Co., Rancagua, Chile, S. A.
GREIG, E. H., Asst. Mine Supt., Burma Mines Ltd., Nam Tu, N. S. S., Upper Burma.
HAMILTON, HENRY L., Pet. & Min. Geol. & Engr., Hamilton & Walker, 609 Carter Bldg., Houston, Texas.
HARES, CHARLES J...........................Geol., Ohio Oil Co., Findlay, Ohio.
HARRIS, J. W., Research Chem., Western Electric Co., Inc., 463 West St., New York, N. Y.
HUNGELMANN, ARTHUR....Chief Metallographist, Illinois Steel Co., Gary, Ind.
KIRTLEY, CHARLES A., U. S. N. R. F., Bureau of Navigation, Washington, D. C.
LASIER, E. L., Materials Engr., Bureau of Construction & Repair, U. S. Navy, Navy Dept., Washington, D. C.
LEWIS, FRANK E., Min. Engr., Cananea Cons. Copper Co., Cananea, Sonora, Mex.
McDOUGALL, DONALD HUGH, Pres., Nova Scotia Steel & Coal Co. Ltd., New Glasgow, Nova Scotia, Canada.
McKAY, G. S..Townsend, Mont.
MATHER, KIRTLEY F.......Prof. of Geol., Denison University, Granville, Ohio.
NABESHIMA, TOMOTOSHI, Min. Engr., Sado Mine, Mitsubishi Co., Sado-gun, Niigataken, Japan.
REED, STALKER E., Asst. Supt., Ojuela Mines, Cia. Minera de Penoles, Ojuela, Durango, Mexico.
ROGERS, R. B................Supt., Northwest Magnesite Co., Chewelah, Wash.
SCHLESINGER, WILLIAM A., Vice-pres., The Radium Co. of Colorado, Denver, Colo.
SMALLEY, OLIVER, Met. & Chem., Laboratory, Messrs. Sir W. G. Armstrong Whitworth Co., Ltd., Water St., Newcastle-on-Tyne, England.
VAN GUNDY, JAY E., Min. Engr. & Operator.................Philipsburg, Mont.
WARREN, WESLEY W., Cons. Engr., Alaska British Columbia Metals Co., 228 Pemberton Bldg., Victoria, B. C., Canada.
WEIR, J. A......Mine Supt., Ozark Smelt. & Min. Co., Magdalena, New Mexico.
WILSON, JOHN CALVIN, Min. Engr., Cornucopia Mines Co., Cornucopia, Baker Co., Ore.

Associates

BERLINER, E. E....................Michigan Smelt. & Refin. Co., Detroit, Mich.
BOHNER, CARL M........................Met., Illinois Steel Co., Gary, Ind.
COOKE, HAMILTON JR., Member, Met. & Testing Staff, Timber Butte Mill. Co., Butte, Mont.
ESTES, C. H., Standard Practice Dept., American Manganese Steel Co., 91 W. 15th St., Chicago Heights, Ill.
HERREROS, P. HECTOR........Supt., Las Vacas Gold Mine, Aconcagua, Chile, S. A.
LAVELLE, THOMAS A., Pres. & Gen'l Mgr., Indianapolis Brass Co., 1012 E. Michigan St., Indianapolis, Ind.
MAYER, D. O. DE LIMA, Testing Engr., Cananea Cons. Copper Co., Cananea, Sonora, Mexico.
NORTH, DONALD FULTON, Min. Engr., Davis Coal & Coke Co., Box 544, Thomas, W. Va

Junior Associates

BURWELL, BLAIR..........Student, Colorado School of Mines, Golden, Colo.
FRIED, J. S., Student, Pennsylvania State College, Box 602, State College, Pa.
KING, KENNETH V.....Student, University of California, Box 57, Berkeley, Cal.
KINTZ, G. MORTON........Student, Colorado School of Mines, Golden, Colo.
KLINGAMAN, GEORGE LEROY, Student, University of California, Berkeley, Cal.
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LEVINGS, W. S................Student, Colorado School of Mines, Golden, Colo.
LI, HUI KWANG, Chief Engr., Zaing Min. Co., 49 Sia Loh Pu Kia, Lin Qui Doo, Changsha, Hunan, China.
ORNELAS, ERNESTO..........Student, Colorado School of Mines, Golden, Colo.
SCOFIELD, LLOYD M..............Student, University of Wisconsin, Madison, Wis.
SIMON, MAURICE......Pennsylvania State College, Box 602, State College, Pa.
TREADWELL, W. A., JR.......Student, Colorado School of Mines, Golden, Colo.
WAIDLICH, DONALD C., Student, Pennsylvania State College, State College, Pa.
WALDSCHMIDT, WILLIAM A., Student, South Dakota School of Mines, Rapid City, So. Dak.
WERBA, EDWARD OLIVER.......Student, University of Wisconsin, Madison, Wis.
WOO, Y. D...................Student, Colorado School of Mines, Golden, Colo.
WOODLIEF, HAROLD E., Student, Michigan College of Mines, Houghton, Mich.

Total Membership, Mar. 10, 1919..............................7248

CHANGE OF ADDRESS OF MEMBERS

The following changes of address of members have been received at the Secretary's office during the period Feb. 10, 1919, to Mar. 10, 1919.

This list together with the list published in Bulletins No. 133 to 146, January, 1918, to February, 1919, and the foregoing list of new members, therefore, supplements the annual list of members corrected to Jan. 1, 1918, and brings it up to the date of Mar. 10, 1919.

ALDRICH, T. H., JR..........................1429 33d St., N., Birmingham, Ala.
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ALVAREZ, PEDRO.........................Ovalle, Coquimbo, Chile, S. A.
AMIDON, CLAUDE E..............................40 Block F, Pueblo, Colo.
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BERG, HASKON A., Asst. Supt., Carnegie Steel Co., Rankin, Braddock P. O., Pa.
BEROLZHEIMER, D. D., Asst. Technical Editor, The Chemical Catalog Co., 1 Madison Ave., New York, N. Y.
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BROCK, CHARLES .... 350 West 55th Street, New York, N. Y.
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BRUNS, C. L., JR. .... 601 West 160th St., New York, N. Y.
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BUTCHER, F. E., Vice-pres. & Gen'l Mgr., Dominion Co., Adams Bldg., Danville, Ill.
CACERAS, FEDERICO GARCIA, Met. Engr., Compania Gallofa-Consolidada, De Colquechaca, Bolivia, S. A.
CALDER, NORMAN L., Care Miss L. Calder, Box 2155, Johannesburg, Transvaal, So. Africa.
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CAMPBELL, JOHN HAYES, Chem. Engr., Robert W. Hunt & Co., 2200, 175 W. Jackson St., Chicago, Ill.
CARON, M. H. .... Antlershotel, Colorado Springs, Colo.
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CHRISTENSEN, H. L. .... Christensen Motor Co., Globe, Ariz.
CLEAVELAND, EARL C. .... Mgr., Deadwood Min. Co., Mogollon, N. M.
COFFIN, WILLIAM C. .... Vice-pres., Blaw-Knox Co., Box 915, Pittsburgh, Pa.
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DE CAMP, W. V., Min. Engr .... Box 462, Edgewater, New Jersey.
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DUDLEY, HARRY C. .... 704 Lonsdale Bldg., Duluth, Minn.
DUNN, DAVID L., Central Coal & Coke Co., 409 West Euclid, Pittsburg, Kansas.
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FRENCH, R. W. .... Dept. of La Union, San Sebastian, Salvador, C. A.
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GLIDDEN, J. T. .... Malecon Osma, Barranco, Peru, S. A.
GORE, BANCROFT .... 148 State St., Boston, Mass.
GRAHAM, STANLEY N. .... 136 Bagot St., Kingston, Ont., Canada.
GREENIDGE, SAMUEL M. .... Leadville Mining Co., Courtland, Ariz.
HALL, MORTIMER L., Research Chem., Electro-zinc Plant, U. S. Smelt., Refin. & Min. Co., Kennett, Shasta Co., Cal.
HANLEY, HERBERT R., Supt., Electrolytic Zinc Plant, U. S. Smelt., Refin. & Min. Co., Kennett, Cal.
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HINDS, JOEL H...U. S. Army.
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HOVER, D. L. C., American Smelt. & Refin. Co., Monterrey Plant,
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HUGHES, WILSON W................Care Lloyd's Bank, Fowey, Cornwall, England.
HUNTER, CHARLES, Gen'l Mgr., The Campbeltown Coal Co., Argyll Colliery,
Campbeltown, Aust.
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INGLIS, J. F..............................Harmony Mines Co., Baker, Idaho.
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MATHER, T. W.....Asst. Gen'l Mgr., Cerro de Pasco Copper Corpn., Oroya, Peru.
MEIER, A. J........A. J. Meier & Co., 1903 Boatman's Bk. Bldg., St. Louis, Mo.
MELITZER, SAMUEL.........................246 Rivington St., New York, N. Y.
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MITCHELL, J. MACDONALD....................W. R. Grace & Co., La Paz, Bolivia.
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NORRIS, R. VAN A., JR.......2d Lieut., U. S. Engrs., A. P. O. 767, A. E. F., France.
PADDISON, L. F., The Sunnyside Min. & Mill. Co., Eureka, San Juan Co., Colo.
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PETERS, RICHARD, JR., Representative, Rogers, Brown & Co., 1000 Morris Bldg.,
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PFOUTZ, CHARLES YALE..Met. Engr., Magna Plant, Utah Copper Co., Magna, Utah.
PILLOW, ALBERT E., Engr., Societe Belge Industrielle et Miniere du Katanga,
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PLATE, H. ROBINSON......................................Sheepranch, Cal.
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RICHARDS, EDWIN R..................526 Kensington Ave., Salt Lake City, Utah.
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ROBINSON, BURR A...........U. S. Rubber Co., 1790 Broadway, New York, N. Y.
ROBITAILLE, A. EDMOND, American Exchange National Bank Bldg., Dallas, Texas.
ROCKWELL, HARRY M................International Smelting Co., Tooele, Utah.
ROESLER, MAX.....................U. S. Geol. Survey, Washington, D. C.
ROGER, EUGENE......................Nessonvant, Province de Liege, Belgium.
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SCHEURER, L. R............North Georgia Agricultural College, Dahlonega, Ga.
SCOTT, HERBERT K................46 Queen Victoria St., London, E. C., England.
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SHARP, WILLIAM.......Wingfield Outside Properties, Box 1305, Goldfield, Nevada.
SHARPLES, S. P...............................22 Concord Ave., Cambridge, Mass.
SHERRY, HOMER K....................................Asbestos, Que., Canada.
SHUMWAY, RALPH W....Mine Supt., Manufacturers Coal & Coke Co., Hellier, Ky.
SHURICK, ADAM T...............................Forest Hill Inn, Forest Hill, L. I.
SIEBENTHAL, W. A...............................Penn Iron Min. Co., Vulcan, Mich.
SMALL, WALTER M.......................................Box 1830, Tulsa, Okla.
SMITH, FRANK A........................279 10th Street, San Pedro, Cal.
SMYTH, JOHN G., Mgr., Elkhorn Div., The Consolidation Coal Co., Jenkins,
Letcher Co., Ky.
SOMERS, RANSOM E., 306 State Hall, Grant Blvd. & O'Hara St., Pittsburgh, Pa.
SOPER, E. K., Geol., Trinidad Petroleum Development Co., Box 175,
Port of Spain, Trinidad, B. W. I.
SOPER, RALPH H..................Box 175, Port of Spain, Trinidad, B. W. I.
SPENCER, FRANK N., Asst. Gen'l Mgr., The New Jersey Zinc Co.,
160 Front St., New York, N. Y.
STANFIELD, THEODORE......................126 W. 74th St., New York, N. Y.
STANLEY, FRANK A..East Auburn, Cal.
STAPLER, JAMES B..........................Instructed to hold everything.

STEIN, PAUL........................American Smelt. & Refin. Co., Hayden, Ariz.
STEPHENSON, F. L..........................515 Delaware Ave., Bethlehem, Pa.
STEWART, LEIGHTON..........................42 Broadway, New York, N. Y.
STINES, NORMAN C., Cons. Engr. to Russian and English Bank,
2 Moorgate Street, E. C. 2, London, England.
STROUT, ERNEST A................405 South Van Ness Ave., Los Angeles, Cal.
STROMBERG, OSCAR.................................Box 24, Brooklyn, N. Y.
THOMPSON, PERCY W...................Richmond Petroleum Co., Meeker, Colo.
THOMPSON, WARREN D........Chile Exploration Co., Chuquicamata, Chile, S. A.
THURSTON, E. COPPÉE................Room 708, 111 Broadway, New York, N. Y.
TURNER, SCOTT, Mining Corpn. of Canada, 1511 Bank of Hamilton Bldg.,
Toronto, Ont., Canada.
UDDEN, JON A., Chief Geol., Sinclair Gulf Oil Co., Room 409,
Burk Burnett Bldg., Fort Worth, Texas.
VAHRENKAMP, FREDERICK H....Vahrenkamp & Elder, Coarsegold, Madera Co., Cal.
VAN WINKLE, C. T.......Min. & Met. Engr., Dooly Block, Salt Lake City, Utah.
VENANCOURT, DE CORNETTE.....................7, Rue Duperre, Paris, France.
VOORHEES, FREDERICK A., Bacis G. & S. Min. Co., Ltd., Apt. 80, Mazatlan,
Sinaloa, Mex.
WAKABAYASHI, YAICHIRO......Mitsu Seitetau Kaisha, Marunouchi, Tokyo, Japan.
WANVIG, JOHN D., JR..............Supt., Orizaba Mine, Box 617, Glendale, Ariz.
WELLMAN, S. T.............................1878 East 90th St., Cleveland, Ohio.
WESTON, CHARLES V., Care Market Street Elevated Railway Co.,
69th & Market Sts., Upper Darby, Delaware County, Pa.
WHITE, JOSEPH L..........................Supt., Bluebell Mine, Mayer, Ariz.
WHITFELD, H. E....................Univ. of Western Australia, Perth, W. Aust.
WILLIAMS, CHARLES F..Mansfield, Ohio.
WILLIAMS, ROBERT Y.............Gen'l Supt., The Hudson Coal Co., Scranton, Pa.
WILKIN, GARRATT S., Mine Mgr., Moscow Min. & Mill. Co.,
462 10th East St., Salt Lake City, Utah.
WILMOT, H. C............................32 West 40th Street, New York, N. Y.
WINCHELL, HORACE V., 1212 First National-Soo Line Bldg., Minneapolis, Minn.
WIRSHING, HERBERT, Mgr., Gasoline Dept., Hull & Bradstreet,
802 Cosden Bldg., Tulsa, Okla.
WITT, HERBERT N..Carson City, Nevada.
WOLVERTON, F. M............Student, Univ. of Wisconsin, Madison, Wisconsin.
WOOLF, WALLACE G................................Box 451, Kellogg, Idaho.
WORMSER, FELIX E........................100 West 91 St., New York, N. Y.
WRIGHT, LOUIS A...........................61 Broadway, New York, N. Y.
YEATMAN, POPE......................Room 708, 111 Broadway, New York, N. Y.
YEN, CHUANG..........Care Mr. Toran Li, Conservancy Engrg. College, China.
YOSHIWARA, SHIGETAKE, 32 Aoyama-Minami-Cho, Nichome, Akasaka, Tokyo, Japan.
ZANG, ADOLPH F., Vice-pres., The Vindicator Cons. Gold Min. Co.,
314 American Bank & Trust Co. Bldg., Denver, Colo.

MEMBERS' ADDRESSES WANTED

Name. Last address of Record from which Mail has been returned.

ARMSTRONG, E. W..................Mina Bibilonia, La Libertad, Nicaragua, C. A.
BACON, MAURICE W........726 Old National Bank Building, Spokane, Wash.
BIRD, FRANK H..............................Butler Hotel, Seattle, Wash.
BLANCHARD, RALPH C.....................3 Lombard St., London, England.
BOYER, SAMUEL L..San Francisco, Cal.
BREEDING, F. O.....................Eden Min. Co., Bluefields, Nicaragua.
DETERT, WILLIAM F................................Jackson, Amador Co., Cal.
HERR, J. CAMPBELL..............................Box 556, State College, Pa.
HUTCHINSON, J. W..................Goldfield Cons. Mines Co., Goldfield, Nev.
KAMMERER, CHARLES.............................Box 412, San Francisco, Cal.
KAY, DAVID NELSON.................Ray Cons. Copper Co., Hayden, Ariz.
KING, FRANK E.............................Hotel Breslin, New York, N. Y.
KLEESATTEL, RICHARD.....................911 White Bldg., Seattle, Wash.
KLUGESCHEID, WALTER P................616 W. 113th St., New York, N. Y.
MUIR, T. K..................309 Trust & Savings Bank Bldg., Los Angeles, Cal.
NAHL, A. C.....................1079 Monadnock Bldg., San Francisco, Cal.
STICKNEY, WILLIAM H.......................708 N. Center St., Reno, Nev.

TAPLIN, THOMAS J., JR..............16 Lordship Park, London N. 16, England.
TINGLEY, T. W...Beutree, W. Va.
TREAT, LLOYD B., Canadian Ingersoll-Rand Co., Bank of Toronto Bldg., Montreal, Canada.
WONG, YIN CHARLES...Rolla, Mo.
WOO, W. K...........M 70 Sing Kong Li, Minghong Road, Shanghai, China.

NECROLOGY

(See also "Died in Service")

The deaths of the following members were reported to the Secretary's office during the month Feb. 10, 1919, to Mar. 10, 1919.

Date of Election.	Name.	Date of Death.
1887	BOORAEM, ROBERT E.	Sept. 21, 1918.
1917	CARLISLE, STANLEY B	Oct. 24, 1918.
1916	CHEN, FAN	Nov. 17, 1918.
1917	CONOVER, C. C	Nov. 7, 1918.
——	DALY, DAVID R	——. —, 1918.

CANDIDATES FOR MEMBERSHIP

APPLICATION FOR MEMBERSHIP.—The Institute desires to extend its privileges to every person to whom it can be of service. On the other hand, it is not desirable that persons should be admitted to membership in classes for which they are not qualified. Members of the Institute can be of great service if they will make a practice of glancing through the list of applicants and promptly notifying the Committee on Membership, or the Secretary of the Institute, of any persons whom they think should not be classified in accordance with the list given.

Applications Lacking Endorsement

Application for membership has been received from Mr. Brink, whose record is given below. This application lacks the necessary number of endorsers, but since this candidate lives at some distance from the headquarters of the Institute, his record is published here in order that any members who are acquainted with him may be advised of the circumstances and may have an opportunity of writing to the Secretary endorsing this candidate.

Members

Cyril Gordon Brink, Transvaal, So. Africa.
Born 1889, Grahamstown, So. Africa. 1900–05, High School. 1906–07, St. Andrews School. 1908–09, Chem., Rhodes Univ., Grahamstown. 1910–15, In Reduction Wks., Norse Gold Mines, Ltd., Johannesburg. 1915–17, Leading Shiftsman, and in chg. of reduction wks., Fairview gold mine, Transvaal Cons. Mines.
Present position—1917 to date: Reduction Officer, Fairview Devonian Montrose Gold Mines, Ltd.

The following persons have been proposed during the period Feb. 10, 1919, to Mar. 10, 1919, for election as members of the Institute. Their names are published for the information of Members and Associates, from whom the Committee on Membership earnestly invites confidential communications, favorable or unfavorable, concerning these candidates. A sufficient period (varying in the discretion of the Committee, according to the residence of the candidate) will be allowed for the reception of such communications, before any action upon these names by the Committee. After the lapse of this period, the Committee will recommend action by the Board of Directors, which has the power of final election.

Benjamin F. Affleck, Chicago, Ill.
Proposed by Charles H. MacDowell, C. C. W. Gennett, Jr., L. V. Rice.
Born 1869, Belleville, Ill. Grammar School, Ill. 1896–1906, Salesman Illinois, Steel Co. 1906–15, Gen'l Sales Agent, Universal Portland Cement Co.
Present position—1915 to date: President, Universal Portland Cemen Cot.

Goodsell Billings, Platteville, Wis.
Proposed by Ralph E. Davis, M. H. Newman, W. N. Smith.
Born 1887, Cobb, Wis. 1905–09, Univ. of Wis. 1906, Instrument man, iron exploration crew, Hammondville, N. Y., District, Oliver Iron Min. Co. 1908, Mapping out, Oliver Co., Canada. 1909–10, Miner, Vinegar Hill Zinc Co., Wis. 1910, Surveyor, Vinegar Hill Zinc Co. 1910–11, Underground Foreman. 1911 to date, Mine Supt., Vinegar Hill Zinc Co. Present position: Supt., Jefferson Mine.

Stephen Eugene Chiapella, Los Angeles, Cal.
Proposed by R. C. Higley, L. D. Osborne, Alvin B. Carpenter.
Born 1882, Biloxi, Miss. 1900–02, Univ. of Southern Cal., Los Angeles, Cal. 1903–04, Assayer and Met., Cherokee Goldfields Co., San Julian, Chih., Mex. 1904–05, In business in Los Angeles, Cal. 1905, Field Repre., Old El Rayo Min. Co., Santa Barbara, Chih., Mex. 1905–06, Old Veta Colorado Min. & Smelt. Co., Parral, Chih., Mex. 1906, Mill and Cyanide Foreman, Guanajuato Cons. Min. & Mill Co. 1907, Night Foreman, Guanajuato Dev. Co. 1907–12, Mill Foreman, Asst. Supt., Supt., The Yude Gold Min. Co., Yude, Dgo., Mex. 1912–13, In business in Los Angeles, Cal. 1913–15, Const. Dept., Engrg. Corpn., Pacific Elec. Ry. 1915–16, Engrg. & Auditing Dept., L. A. & S. L. R. R. 1918, Repre. Chem., The Manganese Assn. Present position: Not employed.

George Richmond Delameter, Steelton, Pa.
Proposed by W. L. Cumings, Hubert Merryweather, C. A. Buck.
Born 1880, Meadville, Pa. 1898–99, Pittsburgh Reduction Co., New Kensington, Pa. 1899–1900, Draftsman with James Bryan, Cons. Engr., Pittsburgh, Pa. 1901–02, Asst. Supt., Lackawanna Coal & Coke Co., Wehrum, Pa. 1903–06, Cons. Engr., Pittsburgh, Pa. 1907–08, Engr. in charge Coal Washing Section, U. S. Geol. Survey. 1909, Supt. Sunnyside Coal Min. Co., Strong, Colo. 1910–11, Cons. Engr., Denver, Colo. 1912–13, Cons. Engr., Pennsylvania Crusher Co.
Present position—1914 to date: Asst. Supt., By-product Coke Oven Dept.

Arthur Erickson, Midvale, Utah.
Proposed by E. H. Hamilton, Robert Wallace, C. A. Lemke
Born 1883, Salt Lake City, Utah. 1899–1900, Salt Lake High School. 1901–06, School of Mines, Univ. of Utah, B. S. 1906–11, Mech. Draftsman, United States Smelt. Co., Utah. 1911–12, Draftsman, Smelter, Mason Valley Mines Co., Nevada. 1912–13, Draftsman and Construction Engr., U. S. Smelt. Co., Utah. 1913–19, Chief Draftsman and Construction Engr., charge of smelter and mill plant, U. S. Smelt. Co., Utah. Present position: Engr., U. S. Smelt., Refin. & Min. Co., Utah.

Oscar A. Fischer, Denver, Colo.
Proposed by J. C. Roberts, M. F. Coolbaugh, I. A. Palmer.
Born 1889, Chicago, Ill. 1907–09, Univ. of Ill. 1909, Armour Institute of Tech. 1910–14, Colorado School of Mines, E. M. 1914–16, Leasing. 1916, Sampler, The Goodrich Lockhart Co. 1917–18, Assayer, Foreman, Engr., The Goodrich Lockhart Co. 1918, Cons. and experimental work.
Present position: Experimental work, Colorado School of Mines.

Joseph P. Fleming, Wallingford, Conn.
Proposed by George K. Burgess, Paul D. Merica, Henry M. Howe.
Born 1886, Wallingford, Conn. 1912, Sheffield Scientific School, Yale Univ., Ph. B. 1912–13, Chief Chem., Seamless Rubber Co., New Haven, Conn. 1913–17, Chem. Engr., Research Lab., U. S. Rubber Co.
Present position—1917 to date: Capt., Ord. Dept., U. S. Army.

Arthur Edward Flynn, Goudreau, Ont.
Proposed by Hugh Park, James Johnston, J. J. Denny.
Born 1890, London, England. 1906–08, Finsbury Technical College. 1910–12, Royal School of Mines, A. R. S. M. D. I. C. 1909–10, Asst. Mech. Engr., F. Reddaway & Co. 1912–16, Surveyor and Min. Engr., Nipissing Mines, Ltd., Ont., Canada. 1916–18, Min. Instructor, charge of Haileybury School of Mines, Ont.
Present position: Supt., Rand Cons. Mines.

Ro Kuzo Furuichi, Iyo, Japan.
Proposed by Tatsuro Otagawa, Kenrokn Ide, C. Yabe.
Born 1885, Niigata, Japan. 1910, The Tokyo Imperial Univ. 1910–18, Min. Engr., Besshi copper mine, Sumitomo Co.
Present position—1918 to date: Mine Supt., Besshi Copper Mine, Sumitomo Co.

Roy Castle Greenfield, Milwaukee, Wis.
Proposed by Pierre R. Hines, Herbert C. Enos, Joseph Furlong.
Born 1877, Oil City, Pa. 1899–1903, Rensselaer Polytechnic Inst., C. E. 1904–05, Electrical Engr., Inguaran Min. Co., Inguaran, Michoacan, Mex. 1905–07, Min. Engr., Trinidad Cons. Min. Co., Toxco, Guerrero, Mex. 1908, Locating Engr., Mexican Light & Power Co., Mexico. 1908–10, Sales Engr., Allis Chalmers Mfg. Co. 1910–14, Mgr., Mexico City office.
Present position—1914 to date: Sales Engr., Allis Chalmers Mfg. Co.

Benjamin G. Harmon, Watervliet, N. Y.
Proposed by William R. Chedsey, J. Burns Read, Boyd Dudley, Jr.
Born 1889, St. Paul, Minn. 1906–10, Minn. School of Min. and Met., E. M. 1910–11, Min. Engr., Paragon Cons. M. Co. 1911–12, Supt., Orofino Cons. M. Co., Idaho. 1912, Millman, Morning mill, Federal Min. & Smelt. Co. 1912–14, Assayer and Met. Chem., Sweeny mill, Federal Min. & Smelt. Co. 1914–15, Examination min. properties, Montana, Colo. and Idaho. 1915–18, Gen'l Mgr., Northern Light Min. & Mill. Co. 1918, Gen'l Mgr., Henrietta Exploration Co. 1918, Engr. of Tests, Ordnance Dept. Carnegie Insti., Army Ordnance Training School. 1918, Engr. of Tests, Inspection Division, Ordnance Dept., Symington-Anderson Co. 1918, Engr. of Tests, Mapec Division, Ordnance Dept., Watervliet Arsenal.
Present position—1918 to date: Met. Engr., Watervliet Arsenal.

Walter Rollo Hibbard, Bridgeport, Conn.
Proposed by T. C. Merriman, Charles Ferry, W. H. Bassett.
Born 1885, Groton, N. Y. 1900–03, Groton High School. 1903–04, Moravian Parochial School. 1904–08, Syracuse Univ., B. S. 1908–10, Instr. of Chem., Penn. Military College. 1910–13, Chem., Experimental Station. 1913–16, Chem., Research Dept. 1916–17, Asst. Gen'l Foreman, Paper Shell Depts., Union Metallic Cartridge Co. 1917–18, Chief Chem., charge of chem. lab., primer testing and storage, and primer mixture mixing. 1918, Research Engr., charge of chem. met. steel treatment, pyrometer, testing and physical lab.
Present position: Research Engr., Charge of Research Dept.

Leonhard Ervik Holmboe, Ben Avon, Pa.
Proposed by W. Lee Heidenreich, W. A. Wilson, J. C. Dick.
Born 1887, Tromsoe, Norway. 1907–12, Univ. of Christiania, M. E. 1912, Cons. work, Thor Lutken, Christiania, Norway. 1913, Surveyor, Braden Copper Co., Chile. 1913–14, Chief Engr., Compania Minera de Oruro, Oruro, Bolivia, S. A. 1914–16, Mgr., Emprisa Minera de Solano, Oruro, Bolivia. 1916–17, Cons. Engr., Arturo Fricke, Oruro, S. A. 1917, Gen'l Mgr., Empresa Minera La Concordia. 1918, Erecting Engr., The General Combustion Co., Chicago, Ill.
Present position: Draftsman, Jones & Co. Inc., Pittsburgh, Pa.

Walter Karri-Davies, San Francisco, Cal.
Proposed by Hennen Jennings, T. A. Rickard, William Wallace Mein.
Born 1867, Adelaide, Aust. 1878, North Adelaide Grammar School. 1880, Scotch College, Australia. 1881–87, Private tuition in civil engrg. and mech. drawing. 1888–89, Building water works. 1890–91, In charge of building water works. 1891–92, Charge Karridale timber estate. 1893, Travelled. 1898, Reported on forests of Rhodesia. 1899–1901, Major, So. African War. 1902, Reported on water supplies, Orange River Colony. 1904, Designed and supplied drawings for Durban harbor. 1904–07, Managed Morning Star diamond mine. 1908, Travelled, inspected mines in Africa, Australia and America.
Present position: Hon. British Asst. Provost Marshal, Cal.

Frederick Farrington Kett, Millbourne, W. Philadelphia, Pa.
Proposed by J. P. Hutchins, R. P. Tinsley, Philip W. Henry.
Born 1882, Chicago, Ill. 1895–99, Armour Inst. of Tech., Ill. 1899–1903, Royal School of Mines, London, England, A. R. S. M. 1903–06, Mill Supt., Melones Min. Co., Melones, Cal. 1906–07, Operating a lease, Atlanta Claims, Goldfield, Nev. 1908, Diamondfield Black Butte property, Diamondfield. 1909–11, Works Supt., Braden Copper Co., Rancagua, Chile. 1911–12, Gen'l Mgr., Swedish Iron Mines & Furnaces, Ltd. 1912–16, Supt., Agbasar copper fields, Siberia. 1916–18, Engrg. staff, American International Corpn., Russia.
Present position: Engrg. Staff, New York Shipbuilding Corpn.

Evan Gerrit Lewis, Anaconda, Mont.
Proposed by Louis V. Bender, Charles D. Demond, Enoch A. Barnard.
Born 1889, Orange City, Iowa. 1906–10, Univ. of Idaho, B. S. M. 1911–12, Miner, Hecla Min. Co., Burke, Ida. 1912–14, Assayer, Atlas Min. Co. 1914, Engr.,

Atlas Min. Co. 1914–15, Flotation Operator, Anaconda Copper Min. Co. 1915, Asst. Testing Engr., Anaconda Copper Min. Co. 1915 to date, Chem., Anaconda Copper Min. Co. Present position: Chem., Anaconda Copper Min. Co.

Paocheng Lu Ku, Peking, China.
Proposed by George I. Adams, Franklin L. Barker, Cheng-Fu Wang.
Born 1890, Nanking, China. 1914, Pei Yang Univ., Tientsin, China, B. Sc. 1915, Student Engr., blast furnace dept., iron & steel works, Hanyang, Hankan, China. 1915–16, Prospecting Engr., Board of Finance, Chinese Government. 1917 to date, Min. Engr., Lin Ho Kon coal mine, Hunan, Central China; Cons. Engr., Chinese Min. Engrg. Agency, Peking, China. Present position: Min. Engr. and Cons. Engr., as above.

Robert J. McKay, Bayonne, N. J.
Proposed by A. E. Wells, G. E. Silvester, P. J. O'Gara.
Born 1887, Shushan, N. Y. 1906–10, Butler College. 1912–13, Univ. of Cal., B. S. 1905–06, Strander, Finisher and Asst. Roller, Carnegie Steel Co., Greenville, Pa. 1911–12, Instructor in Physics and Chem., Kalama, Washington, High School. 1912–13, Asst. Instructor in Engrg. and Physics, Univ. of Cal., Berkeley, Cal. 1912–13, Instructor in Mathematics, San Francisco Y. M. C. A. 1913, Physical Laboratory Asst., Cowell Lime & Cement Co., Cowell, Cal. 1913, Asst. Chem., Alameda Sugar Co., Alvarado, Cal. 1913–14, Asst. Chem., Selby Smelter Commission, San Francisco, Cal. 1915–16, Asst. Chem., Amer. Smelt. & Refin. Co., Murray, Utah. 1916, Chem., Smoke Investigation, Canadian Copper Co., Copper Cliff, Ont., Canada. 1916, Chem. charge smoke investigation, International Nickel Co., Bayonne, N. J.
Present position—1916 to date: Supt. Research Dept.

Jesse George Newton, La Fundicion, Peru.
Proposed by Stuart L. Rawlings, T. W. Mather, E. E. Barker.
Born 1886, San Antonio, Tex. 1907, B. S., Washington and Lee Univ. 1907–15, Assayer, Chem. and Asst. Supt., Monterrey, Velardena and Chihuahua plant of American Smelt. & Refin. Co., Mexico. 1915–17, Supt. of Smelter, Rio Tinto Copper Co., Mexico. Present position—1917 to date: Met. Supt., Cerro de Pasco Copper Corpn.

Guy Nicholas Pfeiffer, Herrin, Ill.
Proposed by C. H. McMahon, Louis Cohen, Alfred W. Pick.
Born 1881, Centerville, Ill. 1901–05, Colo. School of Mines, E. M. 1905, Instructor in Surveying, Colo. School of Mines. 1905–06, Mucker and Miner, various mines in Colo. 1906, Land, mine and irrigation surveys in S. W. Colo. 1907, Assayer, Standard M. & M. Co., Ore. 1907–09, Eng. Supt., min. properties of American Smelt. & Refin. Co. in Mexico. 1910–11, Lecturer on Min. and Mine Surveys, Oregon Agr. College, Ore. 1912, Res. Engr., Union Pacific Coal Co., Hanna, Wyo. 1912–13, Night Foreman, cyanide mill at San Jose de Gracia, Sin., Mexico. 1913, Engr. Cia Carbonifera Aguijta y Anexas, Lampocitas Aguita, Mexico. 1913–15, Various places, Millman and Engr. 1915, Foreman, Mary Murphy mill, Romley, Colo. 1916, Engr., St. Joe Lead Co., Mo. 1917–18, Asst. and Res. Engr., Utah Fuel Co., Castle Gate, Utah. 1918 to date, Engr., Southern Illinois Engrg. Co.
Present position: Engr. in charge of underground work, Southern Illinois Engineering Co.

Edward Van Ness Rawn, Hopkinsville, Ky.
Proposed by Avery H. Reed, J. B. White, W. P. Mitchell.
Born 1874, Saratoga, N. Y. 1894, Pennsylvania State College, B. S. 1899–1901, Time-keeper and Asst. Supt. of quarry works. 1901–04, Supt. tunnel driving, Walton & Co. 1904–05, Gen'l Mgr., constr., Walton & Co., Falls Mill, Va. 1906, Built Schenley Farms Addition, Walton & Rawn Constr. Co., Pittsburgh, Pa. 1906–08, Gen'l Mgr., constr., S. Walton Constr. Co., Falls Mill, Va. 1909, Engaged in construction of railroad yards, opening coal properties. 1910–11, Railroad work at Honaker, Va. Tunnel work, Winston-Salem Southbound R. R. 1911–16, Mgr. and Partner, General R. R. Constr.
Present position: Pres. and Mgr., Southern Mineral Co.

William Robert K. Scott, Gary, Ind.
Proposed by Walter E. Hadley, A. Hungelmann, J. O. Lord.
Born 1888, Burgettstown, Pa. 1911, Penna. State College, B. S. 1911, Open Hearth Clerk, Jones & Laughlin Steel Co., Pittsburgh, Pa. 1911–12, Night Foreman, American Vanadium Co., Bridgeville, Pa. 1912–13, Met. on special steels, Met. Dept., Gary Works, Illinois Steel Co. 1913–15, Plant Foreman, Union Carbide Co., Niagara Falls, N. Y. 1915–16, Research Met., Aluminum Co. of America, N. Y. 1916–17, Chief Met., Standard Chemical Co.
Present position—1917 to date: Met. Engr., Gary Works, Illinois Steel Co., Gary, Ind.

Gordon C. Smith, Boise, Idaho.
Proposed by Walter Hovey Hill, A. G. Van Eman, Robert N. Bell.
Born 1881, Howard Lake, Minn. 1904, Amherst College, B. S. 1904–06, Contract surveys, General Land Office, Idaho and Mont. 1906–07, Engr., Capitol Water Co., Idaho. 1907, Contract surveys for General Land Office in Idaho. 1907–08, Engr., McCarty mines. 1908, Contract surveys for General Land Office in Idaho, Charge of Carey Act Segregation for Idaho Irrigation Co. 1909, Contract Surveys, General Land Office in Idaho. Charge of Carey Act Segregation for Lost River Land & Irrigation Co. 1910, Commercial practice in civil engrg., Washoe Development Co.
Present position: Civil Engr.

Glenn Buchanan Southward, Elkins, W. Va.
Proposed by Everett Drennen, J. W. Knowlton, Frank A. Ray.
Born 1885, Covington, Ky. 1903–08, Ohio State Univ., E. M. 1907, Transitman, Stonega Coke & Coal Co., Big Stone Gap, Va. 1908–11, Asst. Engr., same company. 1911–12, Min. Engr., Log Mountain Coal & Coke Co., Chenoa, Ky. 1912–17, Asst. Chief Engr., Stonega Coke & Coal Co., Big Stone Gap, Va.
Present position—1917 to date: Chief Engr., West Virginia Coal & Coke Co.

Vincent De Paul Splane, Shamokin, Pa.
Proposed by Van H. Manning, D. J. Parker, Robert H. Burrage.
Born 1891, Shamokin, Pa. 1910, Shamokin High School. 1911–17, Engr. Dept., Susquehanna Coal Co. 1917, Pennsylvania Coal & Coke Co. 1917–18, Mine Rescue Station, U. S. Bureau of Mines, Pittsburgh, Pa.
Present position—1918 to date: Sgt., 27th Engrs., France.

Pao-Chen Sun, S. Manchuria, China.
Proposed by Cheng Fu Wang, C. T. Huang, Cho Yang.
Born 1889, Kiang-Su, China. 1904–09, Chih-hi Provincial College. 1909–12, Pei Yang Univ., B. S. 1914–15, Min. Engr., The 2d Mining Office, Manchuria.
Present position—1915 to date: Met. Engr., Pen Chi Hu Coal & Iron Co.

Frederic Edward Twining, Fresno, Cal.
Proposed by Ray Hawley, E. Emory Wishon, Abbot A. Hanks.
Born 1874, Croton, Ohio. 1890–94, Denison Univ. 1894–98, Cons., Chem. private lab. 1898–1904, Chem., Cutter Lab. 1904 to date, Chem. and Mgr., Twining Lab. Present position: Mgr., Twining Laboratories.

Charles Edward Wheeler, Aberdeen Proving Grounds, Md.
Proposed by G. H. Clevenger, H. W. Young, C. F. Tolman.
Born 1890, Lawrence, Kan. 1916, Met. Engrg., A. B., Leland Stanford Univ. 1917, Post-graduate work. 1914, Asst. Furnaceman, Mammoth Copper Co., Kennett, Cal. 1916, Chem. and Foreman, Electrolytic Zinc, American Smelt. & Refin. Co., Omaha, Neb. 1917, Foreman, Lead Refin., Selley Lead Smelt. Co., Selly, Cal. 1917–18, Charge of Met. Lab., Inspec. Division, Ordnance Dept., Washington, D. C.
Present position: Proof Officer of High Explosives, Aberdeen Proving Grounds, Md.

Albert Easton White, Ann Arbor, Mich.
Proposed by W. H. Bassett, C. E. McQuigg, J. Burns Read.
Born 1884, Plainville, Mass. 1903–07, Brown Univ. 1907–08, Grad. Student, Harvard Univ. 1908–11, Research Dept., Jones & Laughlin Steel Co., Pittsburgh, Pa. 1911–13, Instructor; 1913–17, Asst. Prof., Univ. of Michigan, Ann Arbor, Mich. 1917–19, United States Ordnance Dept. 1913–17, General met. cons. work.
Present position: Chief of Met. Branch, Tech. Staff, Ordnance Dept., U. S. A.

Kessack Duke White, New York, N. Y.
Proposed by Mowry Bates, E. M. Shipp, J. F. Kemp.
Born 1887, Louisville, Ky. 1911, Univ. of Kentucky. 1916, Univ. of Chicago, B. S., E. M. 1911–12, Asst., Kentucky Geol. Survey. 1912, Asst. Geol., Illinois Geol. Survey. 1913–'14, Geol., Caribbean Pet. Co. 1914–15, Geol., Standard Oil Co.
Present position—1916 to date: Cons. Geol. in Pet.

Trevett Abbot Wilson, Ray, Ariz.
Proposed by A. A. Wren, S. H. Ball, Allen H. Rogers.
Born 1886, Warren, R. I. 1907–10, Columbia School of Mines. 1910–11, Engr., Summit Copper Co. 1911–12, Engr. and Inspector, Board of Water Supply, N. Y. 1912, Supt., Cave Creek Min. Co. 1912–13, Geol., Caribbean Petroleum Co. 1914–15, Shift Boss, Ray Cons. Copper Co. 1915–18, Efficiency Engr., Asst. Supt. of Mines, Arizona Hercules Copper Co.
Present position: Supt. of Mines, Arizona Hercules Copper Co.

Julius Herman George Wolf, San Francisco, Cal.
Proposed by T. A. Rickard, W. H. Shockley, Courtenay De Kalb.
Born 1874, Edwardsville, Ill. 1893, Mass. Inst. of Tech., B. C. E. 1889-93, Delaware College, C. E. 1893–96, Architects Supt., construction of cold-storage plants, various Eastern cities. 1896–98, Engrg. Asst., Metropolitan Water Supply, Boston. 1898–1904, U. S. Asst. Engr., charge of construction fortifications, San Francisco, Cal.* 1904–05, Asst. Engr., charge of fortifications, Manila, P. I. 1905-06, Operating under lease and gold min. property, Cal. 1906–09, Chief Engr., Tonopah Exploration Co. 1909 to date, Mgr. and Director, oil property, Kern River field, Cal. 1914–16, Pet. Engr., U. S. Bureau of Mines.
Present position—1916 to date: Cons. Engr., Navy Dept., Navy Petroleum Reserves, Cal. and Wyo.

Walter R. Vidler, Cripple Creek, Colo.
Proposed by Robert Sterling, Harold Boericke, F. G. Willis.
Born 1890, Kirkwood, Mo. Cripple Creek Common and High School. 1909-10, Leasing, El Paso Cons. M. M. Co. 1910, Elkton Cons. M. & M. Co. 1910, summer, Free Coinage M. & M. Co. 1910, Mucker, Timberman, Elkton Cons. M. & M. Co. 1910–11, Golden Cycle Min. Co. 1911, Shift Boss, Comanche Plume Min. Co. 1911–13, Sorter-top-man-miner, Cresson Cons. M. & M. Co. 1913–14, Asst. Engr., A. B. Crosley, Cripple Creek. 1914–16, Asst. Engr., Hills & Willis. 1916, Charge of sampling and valuation, Portland Gold Min. Co. 1916–17, Foreman of shooting squad, Portland Gold Min. Co. 1917–19, Examining Engr., Primos Exploration Co.
Present position: Exploration Cruiser and Exam. Engr., Primos Exploration Co.

Associates

Clinton William Ball, Bruceville, Tex.
Proposed by James S. Wroth, Tenney C. DeSollar, W. F. Lewis.
Born 1893, Fredonia, N. Y. 1908–12, Detroit Eastern High School. 1912–13, Marietta College. 1913–15, Michigan College of Mines; summer vacations, Copper Range Min. Co., Painsdale, Mich., Quincy Min. Co., Hancock, Mich. 1915, Asst. Shift Boss, Messina Transvaal Dev. Co., Messina, So. Africa. 1916, Asst. Surveyor, Brakpan Gold Min. Co., Brakpan, So. Africa. 1916–17, British Army, German East Africa Campaign. 1917–18, U. S. Army, 2d Lt., 107 Engrs.
Present position—1918 to date: Capt. 107 Engrs. in France.

Edmund Rudolph Boericke, Boulder, Colo.
Proposed by Harold Boericke, Robert Sterling, George Teal.
Born 1892, New York, N. Y. 1907–11, Philadelphia Manual Training High School. 1911–12, Univ. of Penn. 1912–13, Day Foreman, Harrison Chem. Co. 1913–15, Charge of molybdenum property; 1915–16, Asst. Mine Supt.; 1916–17, Charge of Exploration Dept.; 1917 to date, Field work and Cruising, Primos Chem. Co. Present position: Cruiser and Fieldman, Primos Chem. Co.

Myron A. Dresser, Leonardsville, N. Y.
Proposed by Julius Segall, John R. Roberts, W. H. Emmons.
Born 1894, West Edmeston, N. Y. 1912–14, Univ. of Ill. 1914–17, Univ. of Minn. B. A. & M. S. 1916–17, Asst., Dept. of Geol., Univ. of Minn.
Present position—1917 to date: Geol., Texas Oil Co.

Arthur Edwin Eddy, New York, N. Y.
Proposed by B. B. Thayer, C. V. Jenkins, E. P. Mathewson.
Born Arkansas City, Kan. 1910, Tech. High School, Washington, D. C. 1915, Maryland State College. 1913, Chairman, Public Land Surveys, Mont. 1914, Asst. Valuator, Ches. & Potomac Tel. Co., Washington, D. C. 1915, Field Asst., Forest Service Surveys, Mont. 1916, Met. Clerk and Timekeeper, East Helena plant, American Smelt. & Refin. Co., Mont. 1916–17, Miner, Diamond and Moonlight mines, Anaconda Copper Min. Co., Butte, Mont. Present position: 2d Lt., 24th M. G. B.

Hervy Adelbert Fisher, Pittsburgh, Pa.
Proposed by Newton W. Emmens, W. E. Fohl, Roswell H. Johnson.
Born 1854, Springboro, Pa. Educated at Springboro, Pa. and Conneautville, Pa. 1907–08, Examination of Mica Deposits of Virginia and North Carolina. 1908–09, Vice-pres. and Mgr. Pittsburgh Mica Co., Va. 1909–10, Examination of iron-ore deposits of Va. 1911–14, Investigation of hydro-electric possibilities, Western Md. 1914–19, Principal owner and mgr. of H. A. Fisher Co.
Present position: Mgr. H. A. Fisher Co.

John Ripley Freeman, Jr., Washington, D. C.
Proposed by George K. Burgess, Paul D. Merica, Louis J. Gurevich.
Born 1895, Winchester, Mass. 1912–16, Mass. Inst. of Tech., S. B. 1916, Asst. to Supt., General Abrasier Co., Niagara Falls, N. Y. 1917 to date, Met. Division, Bureau of Standards. Present position: Asst. Physicist, Bureau of Standards.

Clarence Eugene Garland, Damascus, Va.
Proposed by Joseph Kent Roberts, T. Poole Maynard, Victor R. Waite.
Born 1898, Crandull, Tenn. 1911–14, Johnson County High School. 1914–18, Emory and Henry College. 1918 to date, The Smethport Ext. Co., Inc., charge of plant control lab. and products analysis.
Present position: Chem., The Smethport Extract Co. Inc.

John Bozman Kerr, Berkeley, Cal.
Proposed by Benjamin B. Lawrence, Spencer C. Browne, R. M. Betts.
Born 1890, Washington, D. C. 1904–08, Thacher School. 1908–09, Berkeley High School. 1910–15, Univ. of Cal., A. B. 1911, Mine surveying, milling and assaying, Pittsburgh Gold Flat Min. Co. 1914, Operator in cyanide plant, North Star Mines Co. 1915, Operator in smelter, Nev. Cons. Copper Co. 1915–16, Geol., Standard Oil Co. 1916–17, Inspector Cal. State Min. Bureau, Dept. of Pet. and Gas, District of Los Angeles. 1917, Geol., Fuel Oil Dept., Southern Pacific Co. 1918–19, Engr. Corps, U. S. Army, Commissioned 2d Lieut.
Present position: Unemployed.

Hajime Matoba, Cleveland, O.
Proposed by C. M. Young, H. H. Stoek, A. C. Callen.
Born 1887, Tokushima-Ken, Japan. Grad. High School, Kioto, Japan. 1908–11, Spokane High School, Spokane, Wash. 1918, Grad. from the Dept. of Min. Engrg., Univ. of Ill. Present position: Chemist, Patterson Sargent Co.

Earl B. Merithew, Brooklyn, N. Y.
Proposed by J. N. Bartholomew, C. M. Hickok, H. M. Hanna, Jr.
Born 1883, Norwich, N. Y. 1902, Riverview Military Academy. 1902–07, Weedsport Skirt & Waist Co., Weedsport, N. Y. 1907–12, Smith Premier Typewriter Co., Syracuse, N. Y. 1912–14, General Electric Co., Schenectady, N. Y. 1914–16, Dodge Bros., Detroit, Mich. 1916–18, Brown Lipe Gear Co., Syracuse, N. Y.
Present position—1918 to date: Chief Inspector of Ordnance, U. S. A., Utica, N. Y.

Arthur Leon Meyer, Coatsville, Pa.
Proposed by C. E. McQuigg, W. R. Chedsey, C. L. Huston.
Born 1893, Trenton, N. J. 1910–15, Lafayette College, B. S. 1915–16, Asst. Supt., mineral acid production, Harrison Bros. Chem. Mfrs., Philadelphia, Pa. 1916–18, Asst. Supt., zinc mill; Supervisor of Heat Treatment, Midvale Steel & Ordnance Co., Philadelphia, Pa. 1918–19, Commissioned Lieut., charge of met. inspection at Winchester Repeating Arms Co.
Present position: Commissioned Officer, Met. Inspector.

Earl Bart Noble, Springfield, Mass.
Proposed by L. W. Bahney, Arthur F. Taggart, J. F. McClelland.
Born 1894, Springfield, Mass. 1913–16, Yale Sheffield Scientific School, Ph. B. 1916–18, Junior Met., Chile Exploration Co., Chuquicamata, Chile.
Present position: Unemployed.

Fumio Oda, Boston, Mass.
Proposed by Charles E. Locke, H. O. Hofman, Nobuo Yamamoto.
Born 1890, Fukuoka, Japan. 1908, Middle School. 1911, National College. 1914, Kyushu Imperial Univ., M. E. 1914 to date, Min. Dept., Engineering College of Kyushu Imperial Univ.
Present position: Asst. Prof. Engrg., College of Kyushu Imperial Univ., Japan.

Howard Scott, Washington, D. C.
Proposed by George K. Burgess, Louis J. Gurevich, Paul D. Merica.
Born 1893, Rockville, Md. George Washington Univ., A. B. 1912 to date, Various grades from lab. apprentice to Asst. Physicist at Bureau of Standards.
Present position: Asst. Physicist, Bureau of Standards.

Louis Albert Stimson, Syracuse, N. Y.
Proposed by John A. Mathews, Wm. Campbell, Zay Jeffries.
Born 1891, Hope, N. Dak. 1909–13, Oberlin College. 1915–17, Columbia Univ., A. B. 1912, summer, Asst. Chem., Crucible Steel Co.
Present position—1917 to date: Works Met., Halcomb Steel Co.

Edwin See Tompkins, East Orange, N. J.
Proposed by Lewis G. Rowand, George C. Stone, J. S. McKaig.
Born 1893, Brooklyn, N. Y. 1909–12, East Orange High School. 1912-16, Missouri School of Mines. 1914, Mill Operator, Ray Cons. Copper Co., Hayden, Ariz. 1914, Cyanide mill, Ernestine Min. Co., Mogollon, N. M. 1916, Met., Reclamation Research, Balbach Smelt. & Refin. Co., Newark, N. J. Charge of tests and table concentration, New Jersey Zinc Co., Franklin, N. J.
Present position—1917 to date: Sales Engr. and Mgr., The Mine and Smelter Supply Co.

George Frank Wolff, Orange, N. J.
Proposed by George C. Stone, J. A. Van Mater, Lewis G. Rowand.
Born 1875, New York, N. Y. Educated at New York, C. P. A. 1903–08, Chief Accountant, W. J. Buttfield. 1908–13, Senior Accountant, E. L. Suffern Son, Certified Public Accountants. 1913–16, Chief Accountant, Elected Comptroller, The New Jersey Zinc Co. Present position: Comptroller, The New Jersey Zinc Co.

Junior Associates

George Washington Baekeland, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1895, Yonkers, N. Y. 1910–14, Mackenzie School. 1914, N. Y. U. 1915-17, Cornell Univ.
Present position: Student, Colorado School of Mines.

Philip Harris Bohart, Rolla, Mo.
Proposed by C. R. Forbes, G. H. Cox, A. L. McRae.
Born 1898, Fort Worth, Tex. 1916, summer, mill construction, Hill City Tungsten Production Co., Hill City, So. Dak. 1918, summer, underground work, Cresson Cons. Min. Co., Cripple Creek, Colo.
Present position: Student, Missouri School of Mines and Metallurgy.

Frederick Erich Bruhn, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1901, Milwaukee, Wis. 1914–18, Main Ave. High School, San Antonio, Tex.
Present position: Student, Colorado School of Mines.

Iestyn Martin Charles, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1898, Denver, Colo. 1915, Grad. East Side High School, Denver, Colo. 1915–17, Colorado School of Mines, Denver, Colo. 1917–19, Served in U. S. Marine Corps.
Present position: Colorado School of Mines.

William Olwyn Charles, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1897, Denver, Colo. 1909–13, Manual Training High School. 1918, Grad. U. S. School Military Aeronautics, Berkeley, Cal. Engr. Dept., Ray Cons. Copper Co., Ray, Ariz.; Engr. at mine, Primos Chemical Co., Empire, Colo. National Radium Institute, Denver, Colo., under U. S. B. Mines.
Present position: Student, Colorado School of Mines.

James Earley Copenhaver, Emory, Va.
Proposed by Joseph Kent Roberts, T. Poole Maynard, Victor R. Waite.
Born 1896, Seven Mile Ford, Va. 1914–16, Bel Air High School, Bel Air, Md.
Present position—1916 to date: Student, Emory and Henry College.

Perry G. Cotter, Golden, Colo.
Proposed by J. C. Roberts, I. A. Palmer, Victor C. Alderson.
Born 1895, Pardeeville, Wis. 1911–15, High School, Oshkosh, Wis. 1915-16, State Normal. 1916–18, Oliver Iron Min. Co.
Present position: Student, Colorado School of Mines.

Ronald Kinnison DeFord, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1902, San Diego, Cal. 1914–17, San Diego Army and Navy Academy.
Present position—1917 to date: Student, Colorado School of Mines.

Raymond John Thomas Dowd, Rolla, Mo.
Proposed by C. R. Forbes, G. H. Cox, A. L. McRae.
Born 1896, St. Louis, Mo. 1911–15, Yeatman High School. 1917, summer.

underground work, Isle Royal Copper Co., Houghton, Mich. 1918, summer, underground work, Old Dominion Copper Co., Globe, Ariz.
Present position—1915 to date: Student, Missouri School of Mines and Metallurgy.

Elmer Fisher, Corvallis, Ore.
Proposed by G. E. Goodspeed, Jr., Henry M. Parks, A. M. Swartley.
Born 1890, Manning, Ore. 1911–15, Hillsboro High School. 1916, Mining at Cornucopia, Ore. 1917, Head Chairman, State Highway. 1918, Brakeman and Timekeeper, Carlton Consolidated Lbr. Co.
Present position: Student, Oregon Agricultural College School of Mines.

Howard Thomas Flint, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1898, Denver, Colo. 1912–16, North Side High School, Denver, Colo.
Present position—1916 to date: Student, Colorado School of Mines.

Louis Clement Fopeano, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1898, Hoboken, N. J. 1915–18, Emory and Henry College, Emory, Va.
Present position: Student, Colorado School of Mines.

John Philip Grilli, Cambridge, Mass.
Proposed by Edward E. Bugbee, Chas. E. Locke, H. O. Hofman.
Born 1896, Chicago, Ill. Lane Tech. High School, Chicago, Ill. Lewis Inst., Chicago, Ill. Research, coal-tar flotation oils, American Tar Products Co., Chicago, Ill. Research, coal-tar flotation oils, Barrette Mfg. Co., Chicago, Ill.
Present position: Student, Mass. Inst. of Tech.

Sam Grinsfelder, Berkeley, Cal.
Proposed by Ernest A. Hersam, Walter S. Morley, Walter S. Weeks.
Born 1897 Spokane, Wash. 1903–11, Spokane Grammar School. 1911–15, Spokane High School. 1916, summer, underground work, Cons. Interstate Callahan Min. Co., Wallace, Ida. 1917, summer, Lead Refinery, Bunker Hill & Sullivan Smelter, Kellogg, Ida. 1918, summer, Engineering force, Old Dominion Min. Co., Globe, Ariz.
Present position—1916 to date: Student, University of California.

Everett L. Grubb, Indianapolis, Ind.
Proposed by A. N. Winchell, Richard S. McCaffery, W. J. Mead.
Born 1897, Connersville, Ind. 1916–17, Butler College, Indianapolis, Ind.
Present position—1917 to date: Student, University of Wis.

Earl Ball Hardy, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1898, Watertown, N. Y. 1916, Grad. Watertown High School, Watertown, N. Y. 1917, summer, mucking and tramming, Ouray, Colo. 1918–19, summer, Instrumentman, engr. squad, New Cornelia Copper Co., Ajo, Ariz.
Present position: Student, Colorado School of Mines.

Harland Hobart Hoppock, Rolla, Mo.
Proposed by G. H. Cox, C. R. Forbes, A. L. McRae.
Born 1896, Kewanee, Ill. 1912–16, Mo. High School. 1918, Picher Lead Co.
Present position–1916 to date: Student, Missouri School of Mines and Metallurgy.

Carl Bernard Hummel, Rolla, Mo.
Proposed by Horace T. Mann, C. R. Forbes, G. H. Cox.
Born 1897, Florence, Mo. 1903–11, Grammar School, Calfornia, Mo. 1911–15, High School, Calfornia, Mo.
Present position: Student, Missouri School of Mines and Metallurgy.

Henry Waldon Lawrence, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1897, Falmouth, Mass. 1911, Grad. Falmouth Grammar School. 1912–16, High School, Pittsfield, Mass. 1917–18, Univ. of South Dakota. 1916–17, General Electric Co., Pittsfield, Mass.
Present position—1918 to date: Student, Colorado School of Mines.

Julian Stephens Marshall, Corvallis, Ore.
Proposed by G. E. Goodspeed, Henry M. Parks, A. M. Swartley.
Born 1895, Rapid City, So. Dak. 1911–15, Washington High School, Portland, Ore. 1915–17, Agent, Oregon Journal of Portland, Corvallis, Ore. 1917, Star

Mining Co., Mullan, Ida. 1918, Asst. Instructor, Oregon Agricultural College, Corvallis, Ore. 1918–19, Northwest Steel Co., Portland, Oregon.
Present position: Student, Oregon State Agricultural College, School of Mines.

William Ferdinand Netzeband, Rolla, Mo.
Proposed by G. H. Cox, C. R. Forbes, C. L. Dake.
Born 1897, St. Louis, Mo. 1912–14, Yeatman High School. 1918, summer, general laborer, St. Joseph Lead Co., Herculaneum, Mo.
Present position: Student, Missouri School of Mines and Metallurgy.

Will Victor Norris, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1894, Albion, Mich. 1918, William Jewell College, Liberty, Mo., A. B. 1919, two months, Chem., Ozark Smelt. & Min. Co.; six months, Chem., hydrogen plant, U. S. Army Balloon School, Fort Omaha, Neb.
Present position: Student, Colorado School of Mines.

Allen Dewey Potts, Rolla, Mo.
Proposed by Horace T. Mann, C. R. Forbes, G. H. Cox.
Born 1895, East St. Louis, Ill. 1902–10, East St. Louis Grammar School. 1910–14, East St. Louis High School. 1917, summer, refinery of Buffalo Mines Co., Cobalt, Ont., Canada.
Present position—1916 to date: Student, Missouri School of Mines and Metallurgy.

Gerald Franklin Rackett, Rolla, Mo.
Proposed by G. H. Cox, A. L. McRae, C. R. Forbes.
Born 1898, Chicago, Ill. 1912–16, Lane Technical High School. 1912, 4 mo., General work in gold prospecting. 1917, Instrument man in oil surveying, Cosden Oil & Gas Co., Texas.
Present position—1916 to date: Student, Missouri School of Mines and Metallurgy.

Andrew B. Robb, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1898, New Britain, Conn. 1913–17, New Britain High School.
Present position—1917 to date: Student, Colorado School of Mines.

Daniel Charles Sherman, Houghton, Mich.
Proposed by F. W. McNair, F. W. Sperr, J. B. Cunningham.
Born 1896, Houghton, Mich. 1912–16, Calumet High School.
Present position—1917 to date: Student, Michigan College of Mines.

Robert Knox Stroup, Rolla, Mo.
Proposed by G. H. Cox, C. R. Forbes, A. L. McRae.
Born 1894, Lewistown, Mo. 1910–14, Quincy, Ill., High School.
Present position—1916 to date: Student, Missouri School of Mines and Metallurgy.

Norman Everett Thompson, Houghton, Mich.
Proposed by J. B. Cunningham, F. W. Sperr, F. W. McNair.
Born 1897, Houghton, Mich. 1912–16, Calumet High School.
Present position—1916 to date: Student, Michigan College of Mines.

Albert Maitland Turner, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, M. F. Coolbaugh.
Born 1898, LaVita, Colo.
Present position—1917 to date: Student, Colorado School of Mines.

Frederick Williams Uthoff, Rolla, Mo.
Proposed by G. H. Cox, C. R. Forbes, C. L. Dake.
Born 1893, St. Louis, Mo. 1909, McKinley High School. 1917, summer, "Bumper," Doe Run Lead Co., Flat River, Mo. 1918, summer, general underground work, Eagle Picher Lead Co., Picher, Okla.
Present position—1916 to date: Student, Missouri School of Mines and Metallurgy.

Don Carlos Valdez, Golden, Colo.
Proposed by J. C. Roberts, Victor C. Alderson, I. A. Palmer.
Born 1898, Salida, Colo. 1914–17, Salida High School. 1916, Tramming, Madonna mine, Monarch, Colo. 1917, Mining, Madonna mine, Monarch, Colo. 1918, Chemical lab., Burns Invest. Co.
Present position: Student, Colo. School of Mines.

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[1] Until Feb., 1920. [2] Until Feb., 1921. [3] Until Feb., 1922. [4] Until Feb., 1923.

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DATE		TITLE OF POSITION AND CHARACTER OF EACH ENGAGEMENT (Make statement brief and concise: any necessary amplification may be made by letter.) Failure to give complete information will cause delay. Give dates chronologically with every engagement, including consulting work of at least six months' duration. It is also desirable to make mention of important publications and original researches or investigations in laboratory or field work: also inventions and any honorary degrees or other distinctions received. Proper names, names of companies, etc., should be written without abbreviation.	TIME.		NAME AND ADDRESS of some one familiar with each engagement, preferably the person to whom applicant reported.
om	To		Total Time	In Responsible Charge	

Grade	General Requirement	Age (Minimum)	Length of Active Practice	Responsible Charge of Work
Member....	Professional Mining Engineer, Geologist, Metallurgist or Chemist.	27 years	6 years*	3 years
Associate...	Any one interested in mining, geology, metallurgy, or chemistry.			
Junior Associate..	Engineering student who has not received technical degree.			

* See requirements for membership on reverse page.

Received__________

Bulletin__________

Elected__________

Second Notice__________

Third Notice__________

Final Notice__________

Accepted__________

REQUIREMENTS FOR MEMBERSHIP

Extract From Constitution

ARTICLE II

MEMBERS

SEC. 1. The membership of the Institute shall comprise four classes, namely: 1. Members; 2. onorary Members; 3. Associates; 4. Junior Associates.

All members shall be equally entitled to the privileges of membership, excepting that Honorary embers, Junior Associates, and Members and Associates whose residences shall be outside of the nited States, Mexico, and Canada shall not be entitled to vote. Members and Associates residing ithin the United States of America, Mexico, and Canada, and not in arrears for dues, shall be entitled vote in person at the meetings of the Institute, or, as hereinafter provided for, by letter ballot.

SEC. 2. MEMBERS shall comprise all those persons who on the third Monday of February, 1918, ere members of the Institute, and in addition thereto, all those thereafter elected or transferred into e class of Members.

Members must be at least 27 years of age and must have had at least six years' employment in the actice of engineering, mining, geology, metallurgy or chemistry, during at least three years of which ey must have held positions of responsibility in one or more of these fields.

Graduation from the scientific course of a college, approved by the Committee on Membership, all be considered equivalent to two years' employment, as required in the previous sentence.

Employment as a teacher of engineering, mining, geology, metallurgy or chemistry, if in direct iarge, may be considered a position of responsibility as specified in the second paragraph.

Persons employed in research or any scientific literary work or in teaching in the scientific departents of colleges, approved by the Committee on Membership, who at the same time are engaged consulting or in the active practice of mining, geology, or metallurgy, shall be entitled to consider e time so spent in active practice as equivalent to an equal length of time of employment in positions responsibility, provided the work done or the positions held seem to the Committee on Membership warrant the equivalency.

The requirement of three years' employment in positions of responsibility may be waived by the ommittee on Membership in the case of persons who have done notable original work in mining, ology, or metallurgy, or have won distinction by research or investigations in one or more of these ibjects. By investigation or research is understood laboratory experimentation as distinct from vestigations in literature or compilations of the work of others.

ASSOCIATES shall be those, who, in the opinion of the Committee on Membership and the Board Directors, are suitable for such election or transfer by reason of their interest in or connection with ining, geology, metallurgy, or chemistry.

JUNIOR ASSOCIATES shall comprise all students in good standing in engineering schools, who ave not taken their degrees and are nominated by at least three members, two of whom must be their structors. A Junior Associate may remain such not longer than five years after leaving the engineerg school, at the end of which period his qualifications to become a Member or Associate must be passed pon by the Committee on Membership. If elected he shall pay at that time the entrance fee and dues a Member or Associate.

In case there is any question as to the classification of a candidate the Committee on Membership ay require from him any evidence he desires to present and the decision of the Committee as to the oper status shall be final.

Every candidate for election as a Member, Associate, or Junior Associate must be proposed for ection by at least three Members or Associates, must be approved by the Committee on Membership prescribed in the By-Laws, and must be elected by the Board of Directors.

EXHIBITS OF CHARTS, FORMS, ETC., USED IN ARMY PSYCHOLOGY TESTS

Employers and others interested in personnel work will have an pportunity to examine the methods developed by the Committee on Classification of Personnel in the Army at an exhibit to be shown on the uditorium (third) floor of the Engineering Societies Building, 29 West 9th Street, New York City, Apr. 1, 12, 1919. The exhibit consists of a ollection of wall charts, forms, photographs, and models showing how he Army finds out what men can do best and how it uses that information; how soldiers are trade tested, and how officers are rated and fitted ito place; how the work is checked and supervised, and its results in the var.

The collection is being shown under the auspices of the National ssociation of Corporation Schools and the United Engineering Society. t was on exhibition for several weeks at Washington, where it excited so nuch interest that in response to many requests the Adjutant General onsented to its display in other cities. Two commissioned officers ccompany the exhibit to explain its various features.

Principles of Mining Taxation*

BY THOS. W. GIBSON,† TORONTO, ONT.

(New York Meeting, February, 1919)

THE object of taxation is the raising of a revenue. Unless a tax accomplishes this, it is a failure. The right to take for public purposes a part of the moneys obtained from the carrying on of private enterprises is an attribute possessed only by a lawful government, and may indeed be called the supreme attribute of government. In free, democratic communities this power must of necessity rest upon the consent of the governed. Power implies obligation, hence it is obviously the duty of a government, in framing a system of taxation, to provide one which, while effective in producing a revenue, is also just and impartial.

It will be conceded that mines and mining property ought to bear a fair share of the public expenditure. The question is, upon what basis taxation should proceed. Two separate taxing principles are usually contended for: Taxation should be proportionate to the benefits received by the person or property taxed; taxation should be based on ability to pay. A third is sometimes added, taxation should have reference to the extent and value of the natural resources enjoyed.

As applied to mining taxation, it is pointed out by those who support the first mentioned basis that, mines being usually situated in rocky and hence sparsely peopled regions, mining companies are frequently obliged to construct roads, railways, telegraph and telephone lines, schools, water and sewerage systems, and many other amenities and conveniences of civilization, the cost of which in regions better suited for agriculture and consequently more thickly populated, has either been defrayed locally, or can be spread over a sufficiently large taxable group of people to materially lighten the financial burden on the mine. The mining company, it is argued, having made these outlays, should receive credit for them and be relieved of taxation to a corresponding extent.

There may be some force in this contention, but the situation is capable of relief without attempting to place taxation upon so unworkable a basis as the value of benefits received. Who is to be the judge of these benefits, and how are they to be valued? The very existence of a mining company and its ability to carry on business in peace and security, depend on the prevalence of law and order, which is a result of good government. The state provides protection against violence, and courts of law for

* Presented at the joint session with the Canadian Mining Institute.

† Deputy Minister of Mines, Canada.

redress against wrong. The relationships among the social units of a modern well-governed state are so complex and interdependent as to make it impossible to fix, with any degree of accuracy, the money value of the services rendered by the whole, or in other words, the government, to any one unit.

Again, the state existing for the benefit of the individual units and extending its care and protection to all, it follows, in so far as property is concerned, that the greater the value the larger are the benefits which its owner derives from the state, and consequently the greater the tax he should pay. It would seem, therefore, that the first basis—benefits received—really occupies the same ground as the second basis—ability to pay.

The latter basis presupposes the possession of capital productively employed, for it is obvious that taxes could not long continue to be paid out of capital which remained unreplenished. Any tax upon legitimate industry which diminishes the amount of capital available or necessary for that industry is objectionable, for the reason that its effect must be to cripple, or in the end even to extinguish such industry. Moreover, the only source out of which an unremunerative enterprise can pay taxes is its capital. These considerations bring us at once to a recognition of the fact that the burden of taxation can properly be placed only on net earnings or profits.

Adverting to the third ground for taxation previously mentioned, namely, the value and extent of the natural resources owned or controlled, it is clear that this is a suggestion for the taxation of monopolies. Natural resources, though great, are limited and cannot be equally enjoyed by all. A water power easy of development and capable of supplying electric current for a considerable body of people, becomes, let us say, the property of an individual or company. The owner being without competitors, is able to raise his charges to the highest point, which would probably be the level at which energy could be generated by steam or brought in from elsewhere. Few will deny that such profits are a fair subject of taxation.

In a real, though not in so complete a sense, the possession of a valuable deposit of ore constitutes a monopoly. All land does not contain mineral values; indeed, the proportion of valuable mineral land to the entire surface of the earth is very small, and the owners of mineral deposits are monopolists in the sense that they enjoy this advantage over the great majority of their fellow-beings. Where such advantage enables them to make unusual profits, taxation is amply justified.

In the case of the third basis, what is really put forward for taxation is not so much the monopoly, real or fancied, as the profits which it ensures to the owner, and its application logically leads to the same conclusions as those drawn from the second basis or even the first.

Now, mining is a business more than ordinarily subject to uncertainty of result, and if the capital invested in a mine is to be in danger of serious depletion by means of taxes, because "Dame Fortune's fickle smile" has not been won, the effect will not only be disastrous to the particular mine, but deterrent upon the engaging of capital in mining enterprises generally. On the other hand it is true that mines are sometimes profitable on a scale far beyond that of an ordinary commercial business. I need not stop to multiply instances. The copper mines of Michigan, Montana, and Arizona; the silver bonanzas of Virginia City or Cobalt; the gold mines and diamond diggings of South Africa; and the nickel deposits of Sudbury will come to your minds. Returns such as accrue from deposits like these are the sustaining force of the mining industry and enable it to maintain a vigorous existence despite countless individual failures. Nevertheless, if deposits so valuable pass into private ownership, there is nothing unreasonable in regarding them as charged with a lien in the form of a demand that a fair share of the profits derived from working them shall enure to the public benefit.

In applying the principle of taxing profits or net earnings, it is, of course, implied that all the usual and necessary costs of operation shall be deducted from the gross proceeds. These include wages of labor, superintendence, power, explosives, timber, transportation, expenses of marketing, administration, and similar charges. Depreciation of mine buildings and plant should be allowed for on a basis that will amortize their cost during the lifetime of the mine. Mining machinery is valuable only so long as the mine is in operation; when the ore is exhausted it rarely has more than a scrap value.

Initial capital really invested, carefully distinguished from water, should be exempt from taxation, as until it is returned either in dividends or some other form, profits in the strict sense of the term cannot begin. By initial capital is meant the money invested in purchasing the land from the government and in opening up and equipping the mine. It is apparent that should the property be subsequently sold for a larger sum, it would not be equitable, so far as the state is concerned, to treat the additional cost to the new owner in a similar way, for the increase in value simply represents a capitalizing of future profits, the express object of taxation.

Opinions may differ as to whether dividends to shareholders should be reckoned among the expenses of operation, and so go untaxed. It is not the practice of shareholders to refrain from dividing the profits of a paying mine until the entire capital investment is amortized, but rather to require a distribution to begin at the earliest possible moment. Prudent management, in most cases, will be satisfied if a yearly sinking fund is provided sufficient to wipe out capital before the exhaustion point arrives, and there is no unfairness in the state's request to be treated on the same

basis as the shareholders themselves, and to require its tax to be paid out of the gross sum of net earnings, irrespective of dividends altogether. It may happen that the company instead of distributing its profits in dividends, will reinvest them wholly or partly in enlarging its operations, or in new or improved machinery and equipment, or even in the purchase of additional properties. The destination of profits or the purposes for which they are used, being wholly within the control of the company, should not affect the right of the state to its share.

A more fundamental question in dealing with mining taxation, whether on the net profits, ad valorem, or any other plan, is provided by the fact that the assets of a mine are, in the nature of things, vanishing assets. The first bucketful of ore raised from a mine marks the beginning of the end. The rich storehouse which it has taken nature ages to fill is ransacked by man in a few years. Fairness requires that this special feature of the mining industry should be given full weight in any system of taxation.

This would not be a difficult problem if the end could be foreseen from the beginning, and if the years of a mine's life could, like those of a man's life, be estimated by actuarial methods. Borings, shafts and cross-cuts, in the case of large homogeneous masses such as bodies of iron or copper ore, may give reliable data for such a calculation, but in many cases these methods besides being expensive are difficult of application and uncertain in results. Besides, while the drill is at work and reserves are being blocked out, ore is being raised and treated, shareholders are clamoring for dividends, and the state is asking for taxes. The most that can be done in many instances is to make a conservative guess and proceed accordingly, subject to adjustment as development goes on.

The practical problem, however, for taxation and dividend purposes, is not how long will the mine last, but how soon can the initial capital investment be recovered? After such recovery, the entire net proceeds of the mine may safely be regarded as profit, and treated accordingly.

Usually it will be the part of wisdom to make the period for capital replacement as short as possible. Pressure for returns, however, is imperious and not to be resisted, consequently it is not the usual practice of companies to formally amortize their capital out of net earnings, but rather to pay these out as dividends. The effect of large dividends on the market value of shares is usually very marked, hence the price of shares in large dividend-paying mining companies, is almost invariably too high, since investors overlook the fact that a mine, unlike a farm, cannot be worked forever.

It is sometimes urged that the taxation of profits should be equated over a period of years so as to avoid heavy fluctuations of revenue, which are inconvenient to the state or local body dependent upon mine tax receipts for financing. It should be remembered, however, that, especially

in precious metal mines, the rise and decline of a property cover usually a comparatively brief period. A mine can best pay a large tax when it is earning large profits, but when the end is in sight and profits dwindle the ability to pay is lessened. The adoption of a five- or even a three-year term, would undoubtedly tend to shift the high point of taxation to a later period in the mine's history, and might entail a burden on the closing years which they could not rightly bear. On the whole it seems advisable to close the account at the end of each year.

The net earnings or profits basis for taxation appeals to the sense of fairness. If the mine is a failure, the state receives nothing; if moderately successful, the state gets a moderate return; if it prove a bonanza, the state revenue benefits accordingly. The incidence of taxation is better adjusted than under any other form. Experience has shown it to be acceptable to the mining community itself, which is a strong recommendation. The taxing authorities must of necessity be clothed with sufficient powers of enquiry and examination, and adequate penalties provided for offenses. Given these, the difficulty of enforcement is reduced to a minimum.

The fact is that in any method of mining taxation, excluding those which are admittedly arbitrary in their nature, the underlying principle is taxation of profits. This is borne out by an examination of the ad valorem system in vogue in many States of the Union.

State constitutions almost invariably have imbedded in them a provision that all properties shall be assessed for taxation, and that taxation shall be uniform. This provision precludes any method of taxation avowedly based on output or profits, as well as a specific tax of any kind on mining property or products. In a few of the States the constitution permits specific taxes, but the prevalent basis of taxation is the assessed value of tangible property, to which a uniform rate of taxation is applied. Ordinarily the requirement is for assessment at the actual value, but in practice this provision is disregarded, and in most cases the assessment value is less than the real value. Some States have regularized this disregard, and provide that the assessment shall be for only a specified percentage of the actual value. The valuation is made by the local taxing authorities, and is the basis upon which is levied both State and local taxation.

Most States have now a State Tax Commission, also a Board of Equalization, which may or may not be the same body. The assessment of mining properties by local officials is naturally far from uniform, and the function of the Equalization Board is to adjust the valuation to a common standard. It is obvious that while within the area of a local taxing unit, be it town, city or county, if the same rule of assessment be applied to all properties, it is a matter of indifference whether the basis is 50 per cent., 75 per cent., or the full actual value, for the same rate is applied to all.

For purposes of State taxation, however, it would be inequitable to collect the same rate on properties in a town assessed at 50 per cent. or 75 per cent. of their value; as upon properties in another town appraised at their full value; hence the necessity for the process of equalizing.

But even in estimating the amount at which a mine of any magnitude should be valued for taxation purposes, it is evident that a degree of skill and experience is required, little likely to be possessed by the local assessor. Mere guessing at the value produces endless confusion and irritation. In some of the States of first class mining importance, notably Michigan and Minnesota, the Tax Commissioners determined to adopt some more scientific method. The Michigan mines are of iron and copper. The ore bodies are extensive and valuable. Local conditions, chiefly the fact that the mines are confined to the northern peninsula and the farming lands of the State to the lower peninsula, led to perennial dispute as to the share of taxation which the respective sections of the State should bear. In 1911, the State Tax Commission employed J. R. Finlay to survey and value the iron and copper mines for assessment and taxation purposes. In making this valuation Mr. Finlay applied five factors: (1) Tonnage of ore contained in mine; (2) estimated life of mine; (3) cost of operating; (4) annual receipts from sales of ore; (5) rate of interest for ascertaining present value of deferred production.

The diamond drill is the distinctive tool for exploring the iron mines of Michigan. Most of the mining companies who had been operating for any length of time had delimited their ore bodies by borings, and had ascertained their approximate dimensions and consequently the reserve tonnage. Their average production during the four or five years previous, divided into their ore reserves, gave the probable life of the mine. Operating expenses deducted from receipts from ore sales gave the profit per ton; this figure, multiplied by the average output, gave the yearly profit, or in other words, constituted an annuity payable until the mine was worked out. The present value of this annuity, discounted at 6 per cent., Mr. Finlay set down as the valuation of the mine for taxation purposes. Taking a concrete case, for the sake of clearness, let us assume that Mr. Finlay was valuing the Ferrum mine. On the basis of the company's borings and allowing for probable undiscovered ore, the contents were 10,000,000 tons. The average production was 500,000 tons a year, hence the mine had a future lifetime of 20 yr. The average cost per ton for operating was $3, and the average price for ore sold $3.50, leaving a profit of 50 c. per ton; this, on 500,000 tons of ore would give an annual profit of $250,000 for 20 years, the present value of which was $2,867,475. This sum would be the valuation of the Ferrum mine.

Iron mining in Michigan has had its ups and downs. In 1914, when the great struggle of the nations broke out, the average loss per ton of ore to the mining companies was $0.07712, yet the taxes collected from them,

based on Mr. Finlay's valuations, were equal to $0.12009 per ton. In 1915, there was an improvement. The output of the iron mines was 13,151,612 tons and the average selling price was $2.79402 per ton. Much of the ore is mined subject to royalty payable to the owner of the fee, the average in 1915 being $0.23136 per ton. Including the royalty, the average profit of iron ore was $0.52380 per ton. Out of this margin the royalty charge had to be met, and in addition, taxes rqual to $0.13784 per ton. That is to say, the net profit remaining to the mining companies, after allowing for certain other smaller items, was $0.14674 per ton. Thus, after deducting expenses of production from the selling price, nearly one-half of what was left went as royalty to the fee owner, and the remainder was divided almost equally between the mining company and the tax collector. Before payment of the royalty the taxes amounted to 26.31 per cent. of the profits; after payment of the royalty, to 47.13 per cent. Judged by pre-war standards, this is pretty heavy taxation.

Mr. Finlay's method has the merit of being systematic, and it takes into account the essential factors of value, but it is evident that no allowance is made for the unexpected. A demand may arise for iron ore far in excess of anything previously known, with a corresponding increase in price and consequently in profits. On the other hand, stagnation may set in, prices may fall, and iron ore may become practically unsaleable. In the former case the valuation of the mine, based as it was on normal conditions, was too low; and in the latter, too high.

In Minnesota a similar method is in vogue, but a somewhat elaborate classification into productive and unproductive mines and prospects, with a varying standard of valuation in the several classes, has been worked out in the endeavor to arrive at equitable results.

The Finlay valuation of the Michigan iron mines gave them a total value of $129,000,000, which was a large increase over the total valuation under the old methods. The companies protested vigorously, and the Tax Commission reduced the valuation to about $90,000,000. At about this figure it practically remained stationary for a number of years, the amount of ore brought in sight year by year equaling the amount extracted.

In the case of the copper mines, the Finlay system had an entirely different result. The aggregate value reported was $69,000,000. This sum was so far below the total of the previous valuations, and also so far below the value of the mining properties as shown by the market value of their shares, that the companies, fearful of the bearish effects upon the stock market, demanded that their old assessments be restored. This request the Tax Commission also granted, and the copper mine valuations have remained at about their old figures.

Whatever may be urged in favor of the Finlay method of valuation as applied to the copper and iron mines of Michigan and the iron mines

of Minnesota, with their immense masses of ore capable of fairly accurate delimitation and ascertainment of quantities, and individually fairly uniform in quality, it is clearly inapplicable to deposits such as those of the precious metals, where the veins are small and subject to great irregularity in their size and direction, and the value of their contents. The diamond drill cannot be depended upon to the same extent in disclosing the value of the deposits. There are other minerals of value notoriously pockety and capricious in their habit; for all such the Finlay method is unsuited. In many cases it could not even be tried, for the essential requirement in estimating tonnage, namely diamond-drill borings on a sufficient scale, is lacking. Even where orebodies are large and of fairly uniform value, unless there has been this preliminary examination by the drill, the necessary data are absent. Cases can be cited where mining companies, even after years of working, were uncertain or even ignorant of the size of their deposits. To make a notable instance from the Province of Ontario; the Canadian Copper Co. working the Creighton nickel mine, were apprehensive that its productive limits were being reached, and consequently prepared to exploit the Frood mine, another large orebody, but lower in nickel and copper contents. They built a town, laid out streets, equipped the new mine with machinery and hoisting plant, and began to work it. Concurrently they continued to explore the Creighton by diamond drilling, and encountered at lower depths unexpected and very large reserves of ore. It paid the company to cease all work at the Frood and to continue operations at the Creighton. Had a valuation been made of the Creighton mine on the Finlay plan before the reserves were disclosed, it would have fallen far short of the correct amount.

Undoubtedly one effect of the Finlay system in Michigan and Minnesota has been to discourage exploration for ore. As soon as the drill brings ore into view, it is subject to valuation and taxation, notwithstanding that it may not be actually worked for years. Every prudent mining company desires to know its position regarding reserves of ore, so that it may be justified in making adequate capital expenditures for the winning and treatment of the same, but if to establish new orebodies is to materially increase their taxation, the result is apt to be a slowing down of the drill.

It is apparent that the Finlay or any other method of mine valuation in the end rests on profits. Unless a deposit can be worked so as to yield a return greater than the cost of working, it has no real value. The controlling factor is the profit per ton or other unit of production. The sum any mine is worth depends upon the profit it is producing, and will continue to produce. When the object is revenue, not a sale, surely the more logical way is simply to tax the profits as they are realized. Since these cannot be accurately predicted, they cannot be accurately

capitalized; nor is there any occasion to do so, for if they prove smaller than was expected, the tax is less and no injustice has been done; should they prove greater, the tax is larger in proportion. The net-profit system automatically adjusts itself to the conditions for the time being, and takes account of all changes in expenses and returns.

Other methods than the taxation of profits have been attempted. One of these is an area tax—so much per acre, hectare, etc. This is a rough-and-ready method, and has no relation to value or ability to pay. An acre of barren rock pays the same tax as an acre of diamond-bearing earth, or of the richest quartz. A second method is a specified rate per unit of mineral, be it ton, pound, ounce, or gallon. This has the same convenience of application as the acreage tax, but takes no account of profits or expenses. A ton of coal scraped from the last workings of a mine would pay the same rate as a ton produced from the richest and most easily worked seam; an ounce of gold wrung from ore carrying $2 a ton, at a profit of ten cents, will pay as much as gold from $50 quartz; a gallon of petroleum from a well yielding a barrel a month, as much as a gallon from a gushing geyser. Such methods of taxation are easily applied, but are unscientific, and lack the essential feature of fairness.

Discussion

Alf. G. Heggem, Tulsa, Okla.—I have listened to the reading of these papers with much interest and feel that perhaps I can add another viewpoint to this subject of taxation based upon experience in paying income and excess profit taxes on manufacturing supplies as well as on producing oil. Dr. Arnold has said that the principles of taxation are not open to discussion. I feel that this is just the feature we should discuss for in the application of the general principles laid down I feel that the Commissioner of Internal Revenue has endeavored to use the utmost fairness with results that must appeal to all as the most satisfactory that can be obtained under the existing principles.

Excessive rate of taxation results in reduced revenue for the government. I recall one direct instance where the first well drilled on a lease of 200 acres produced over 1200 bbl. the first 24 hr.; an offer of $1,250,000 was made for the property but refused as the tax on excess profits was then fixed at 60 per cent. which would have left the owners with less than a 40 per cent. profit. It therefore seemed better to take the annual income from the property at a lower rate of tax and eventually get a much greater return. There was also a fear of an 80 per cent. tax being levied. The result was that if the 20 per cent. tax which has since been assured us had been in force the sale would have been made and the government would have received $250,000 on that transfer and the same taxes on production it has been getting. Incidentally, the value of that property

has dropped about 75 per cent. so the tax would really have been levied on a surplus of capital above real value. This case is typical not in decreased value but in the effect of excessive taxation closing the avenues of revenue to the government.

In the mid-Continent field, while development have been very active in the effort to produce a maximum of oil for war purposes, there have been practically no transfers of property during the past 12 months. The sales of property terminated along about March of last year, as soon as the people began to see what the tax effect would be. Some transfers were attempted on deferred payment basis, an evasion of the tax law that did not get very far. The whole effect of high taxation has been to retard the industry and reduce the revenues. If we can keep our taxes at some point that will not interfere with the activity, the government's revenue will be at a maximum and far greater than it can be under excessively high taxes.

Industry, Democracy, and Education*

BY C. V. CORLESS,† CONISTON, ONT.

(New York Meeting, February, 1919)

We are living at a period of the world's history in which social phenomena are on so vast a scale, are of so profoundly soul-searching a nature, and are occurring in such rapid succession in the great world drama in which we are both actors and spectators, that, in our efforts to obtain a rational point of view in relation to them, our minds may fail to discern the simple in the complex and our understanding is liable to become confused or even overwhelmed. To the social student whose scientific training has convinced him of the truth of the evolutionary law, *Natura non facit saltum*, it is neither the vast scale of the events, their deeply soul-stirring nature, nor their rapid succession that matters so much, as the discovery of the underlying principle or law in accordance with which the disintegration and reintegration, which are the two aspects of social evolution, or indeed of evolution everywhere, are occurring. He is most deeply concerned in seeking an answer to the question: Have we in the present great and perplexing upheavals in human society, whether regarded in Central Europe, in Russia, in Great Britain, or in America, a really new cause at work, or, have we, though on a very large scale, merely new manifestations of the working out of an old principle?

When we think of the appalling struggle in Europe, into which the world's greatest exemplar of democracy was finally drawn, no one has any hesitation in admitting that the great conflict was fundamentally a life-and-death struggle for self-preservation and self-propagation on the part of autocracy. The variations we meet with in the statement of the cause of the war arise mainly from differing distances of perspective; but in the last analysis all agree that the autocratic system of political government, which found its very soul and center in Prussian despotism, was consciously arrayed in a final "world-power-or-downfall" struggle against a love of freedom which was steadily widening and deepening throughout the world, and particularly throughout those parts of the world where this love of freedom and justice has found expression in democratic institutions. It is not irrelevant to our discussion to recall in passing that this most imposing structure ever conceived by the human mind as an instrument of tyranny is lying today an irretrievable mass of ruins, completely over-

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† The Mond Nickel Co., Ltd.

a principle that has divided and shaken, and is at the present moment dividing and shaking, the world of man to its very foundations, surely it is time we took the trouble to grasp it clearly, surely it is time we ceased playing and jockeying with the issues raised by it and, like men of full mental stature, frankly recognized it and deliberately so shaped our conduct as to accord with it. Evasion, under such circumstances, is senseless. What is needed is clear and fearless thought, decision, and resolution. It is not sufficient excuse that we cannot clearly see all the details of our future progress. In this matter, we may well take a lesson from your honored President in dealing with the principle of the League of Nations. We should clearly and fearlessly grasp and stick to the principle, knowing that errors in detail will be more easily corrected than failure in principle.

The sooner we recognize this single, simple principle as the root cause of the existing industrial antagonism, just so much the sooner shall we begin to work intelligently toward a permanent solution of the problem which faces us in the continual, but often clouded, struggle between capital and labor. Any step taken in clear recognition of this will be a step nearer the real solution of the problem. Other steps may be taken from the best of motives, they may be based on the most humane feelings, they may be fully justified and worthy of the highest commendation, but if they do not in some way conduce to this end, they will not assist in effecting a final solution of this great industrial problem. It is better for us to take time to see the goal clearly. Then we shall be able to judge intelligently as to our progress toward it. Society has abolished open slavery of all kinds. America did this at enormous cost in blood and treasure. The difficult problem now is to abolish gradually, and with as little economic confusion as possible, every other form and semblance of autocratic rule. Industry must now gradually come to be ruled by the intelligent consent and approval of all the interested parties. Industrial unrest will continue and will increase until society recognizes this and takes such steps as will secure suitable organization and sufficient general economic intelligence to effect it. We cannot stop half way. Democracy will not be content with mere political and municipal control. It will never leave the matters that affect most deeply and intimately our very existence and manner of life to the autocratic decisions of a few, no matter how worthy or how intelligent they may be.

England already recognizes this and, as you are all now fully aware, has, under the Whitley scheme, of which I gave a brief preliminary account before the Canadian Mining Institute last Spring, adopted the idea as a government policy. Her industries, in particular those most highly organized on the side of both capital and labor, are being organized under this scheme. Many Joint Industrial Councils are already formed. No doubt you in America will watch the organization and the working

out of the functions of these with the greatest interest, as we shall in Canada. This government recognition of the principle of representation of the governed in industrial relations is a first, but an enormous, step in the right direction.

A fair and proper sharing in the control of industry among the several coöperating factors will gradually bring about that feeling of interest and responsibility and that just division of the joint product among the interested parties which will restore the incentive to do one's best and will make industry once more, as it should always have remained, the handmaid of human welfare. Industry, properly conceived, is not something to seek to run away from as long and as frequently as possible, for holidays. Work, done under proper conditions and with the right attitude of mind, can be made so mentally stimulating as to yield very real pleasures of its own. When it does thus stimulate interest and thought, it ceases to be drudgery and no longer fills the mind of the worker with envy and bitterness. When a man has reason to take deep interest and pride in his work because he, jointly with others, contributes his energy and intelligence to a common result or product in which he is interested and in which he is convinced he will have a just share, he will cease to watch the clock and will experience some of the real joy of work of which we hear so much. We need only analyze our own experiences to realize the truth of this. Any doubts we may have as to the exact truth of this probably arise from our daily experience with men whose independence and self-respect have been, in part at least, lost, owing to long years of domination by our existing industrial system. Probably the most pernicious defect of the existing system is this gradual undermining of the workmen's personal responsibility, interest, and self-respect, which are so essential to the development of personality and character.

The British machinery appears to be based on the right principle. The Joint Industrial Councils (of national scope in each industry), the District Councils, and the Shop Committees are based on equal representation of capital and labor. That experience in its operation will prove considerable modification, adaptation, and adjustment to be necessary, is to be expected, as in the case of any other new machinery; and that difficulties will arise from time to time, particularly in the less organized or wholly unorganized industries, is a practical certainty. But, if machinery is designed on the right fundamental principle, such alteration and adaptation merely indicate progress and are easy. If designed on the wrong principle, the more the machinery is perfected the deeper are we plunged into the original error.

There can be little doubt that in recognizing the representative, or democratic, principle in industry and in adopting this principle as the basis of a national industrial policy, Great Britain has started on the right track. It is peculiarly appropriate that England, the mother of

parliaments as well as of the modern industrial system, should now take the lead in introducing the parliamentary idea into the organizations for controlling industrial relations, as a principle of national economic reconstruction. But let no one confuse starting in the right direction with completing the journey; creating machinery, with carrying out the work the machinery was designed to accomplish. The journey is only begun and it promises to be very long and beset with many difficulties. The history of political democracy should warn us of this. The work to be performed by this new machinery will be vast in amount. Though, if it gradually removes the deep cause of the present antagonism and thus restores a high efficiency in industry, it will be the means of adding greatly to the national wealth, contentment, happiness, and prosperity; yet, because it will surely affect the distribution of wealth, it may ultimately mean serious apparent economic loss to many individuals. All the more does society need once for all to assure itself that the underlying principle it is adopting is right and just to all.

Has any one any doubt of this? Has it ever proved to be true that any people, or any section of any people, can safely entrust any aspect of their progress and well-being to any other people or class? Has it ever proved otherwise than that both parties were injured? Have you any knowledge of any instance which did not tend toward moral degeneration of both sides of such an arrangement? Do not present industrial relations further illustrate the truth of this? Have we not all some experience of the moral degeneracy that has resulted in industry from failure to recognize this principle?

Our industrial machines have been turning out two products. We have so far intently regarded the one and largely neglected the other. But the human product, which has been largely neglected, is of infinitely greater importance than the material product. Our aim has been so to beneficiate the material entering our plant that it may be of increased economic value when it leaves the plant. But, if we do this at the cost of shrinkage in value of the personality of those operating the plant, where is to be the recompense? Can this loss justly be compensated by wages, or by dividends paid to some one else? Do you know of any conditions under which human personality does not deteriorate, except those of freedom? Does the present method of organizing industry by a few, generally without consultation with or representation of the many others who are intimately concerned in it, secure this feeling of freedom? I believe that all morally just and honest men who will take the trouble to think out the fundamental issues of this industrial question, with sufficient clearness to grasp the principle involved, will readily admit the justice and rightness of the general principle on which the Whitley scheme, adopted as a labor policy by the British Government, is based.

If this opinion is right, if the democratization of industry is the

principle from which all real progress in adjusting industrial relations must start, then we can hardly dwell on this matter too long or too thoroughly. It is necessary to saturate our minds with it so thoroughly that it will gradually change our habits of thought and action, that it will permeate all our views and change all our attitudes and feelings toward our fellow men in industry. When we have thus become thorough converts to this view, there will be some hope that organization to give effect to it may have a chance of success. Not otherwise. This is at bottom essentially an ethical question. If democratic organization is not based on conviction, I fear it will prove to be a form without spirit. But it is further necessary that we seek to propagate this view as widely as possible. For these principles cannot be carried out by individual firms with complete success. Economic organization is no longer local; in very few respects is it even national; more and more is it becoming cosmopolitan. Hence we should avail ourselves of every opportunity to discuss this question publicly; and it is even more necessary that, in our capacity as citizens, we should give voice to the demand that our educational systems give greater attention to these social and moral questions in the programs of our schools and colleges. As quickly as possible, these institutions should be adapted to meet society's present, urgent, social and moral needs.

For, consider for a moment what will happen in these Joint Industrial Councils if each side comes to the discussion without such sound and sane knowledge of economic questions and such ethical views as will create in the minds of both parties common standards of social justice and right. On any issue of importance the work of the representatives will end in either of two very undesirable results. Either the deadlock between the trade unions on the one side and the employers' associations on the other will have been transferred to a debating organization in which neither side can bring conviction to the other; or, even if the discussions that occur in the Industrial Councils do bring about a satisfactory compromise, such decision will be refused acceptance by the rank and file. Until both parties to the disputes are educated in economic matters up to the degree at which they can grasp clearly what is economically possible and what is socially best, and until they have clear ethical views as to the real end and purpose of all industry as social service, in other words, until they are so educated, either in early life or later, that they have the mental attitude and training practically acquired which will enable them to grip clearly and rationally these complex social, economic, and ethical questions when fully discussed with them, of what use can the mere creation of this new democratic machinery be?

With labor sharing thus in the control of industry, one of the problems that will ultimately, but inevitably, come to the front for discussion and settlement will be the principles on which must be based the equitable

distribution of wealth—a fair sharing of the joint product of industry among labor, capital, management, and the community. The growth of human intelligence is making possible the production of very greatly increased wealth, that is, goods and services of all kinds necessary to supply the needs and desires of human beings. Surely the further growth of intelligence, if accompanied by a corresponding growth in moral feeling and purpose, will gradually solve the problem of preventing the partial frustration of the great purpose for which wealth is created; viz., human well-being, the highest degree of which can be brought about only by its fair and just distribution. But this is an economic and ethical question of the greatest complexity and it lies at the very core of many other economic questions, for all of which a just and practical solution must be found. Nor is it just that the solution of this difficult but important question should be left mainly in the hands of two or even three of the four interested parties. A thorough study and discussion of it by all four interested parties is the only just method. No other method would be thought of under any other than the semi-autocratic conditions prevailing in industry. We are safe in saying that very few, if any, today have given sufficient study and thought to this question, though of such basic importance, to state clearly the principles in accordance with which details of a just and right solution may be worked out in any given case. If I mention this quesion, it is not done with any intention of suggesting that I have reached clearly defined views on this vitally important matter, or of causing needless agitation by raising one of the most burning of economic questions, but rather that we may count the full cost of democratizing industry before deciding deliberately to adopt the principle. As stated, once the initial step is taken, I believe the only logical advance will lead inevitably to this problem. If, as seems inevitable, industry is to be democratized, whether agreeable to all or not, and if this is to be effected in the highest interest of all, then all sections of society should somehow be trained to think economically, socially, and ethically, so that at least a large majority will be in a position to appreciate the justice of the best solution of this and other difficult economic problems connected with industry.

The economic and ethical mental equipment for this, I believe, can best be formed by a rational educational system—a system that regards as its central aim the efficient preparation of oncoming citizens for citizenship in a commonwealth that aims to be democratic through and through, in industry as well as in matters of civil and political government. This is, in my judgment, the surest, if not the only, method by which society can avoid the economic confusion and distress, if not revolution, toward which we appear to be heading. I fear these distressing conditions may come about, if we do not clearly and frankly recognize the tendency of the present almost universal social movement and make ade-

quate preparation, by widespread social and ethical enlightenment, to guide and assist it. Our general educational systems should be so adapted as to prepare those who will tomorrow provide the capital and perform the mental and physical labor connected with industry for a steady growth in an intelligent application of the democratic principle to industry. Industrial peace will never be attained as long as capital and management assume the right to a final say on matters intimately affecting the welfare and even the self-respecting existence of a very numerous class, whose loyal coöperation is as essential to the success of every industrial enterprise as their own.

Is it clearly recognized that we are at the beginning of a great transition period in industry? Do we realize that the autocracy of capital is coming to an end? Such periods of widespread, rapid, social change are times of peculiar danger. It is in the power of the present members of society either to recognize the principle at work and to lend intelligent assistance to the movement, or to increase the social danger by opposing it.

There is, unfortunately, here and there, a revolutionary element in labor, usually arising from a vague sense of injustice which urges the mind toward aspirations, frequently impossible of attainment. Unless there exists a fair knowledge of economic facts and principles, making clear to all parties what is attainable and by what methods, and unless there exists also, in the great majority, moral purpose and determination, revolutionary schemes may have every appearance of being not only practical but legitimate and just. There is also, even among persons of fair general education who have paid but little attention to social and economic questions, too prevalent a belief that society can easily be reconstructed along the lines of some simple, socialistic formula; a belief, in other words, that a new social world can quickly be built by constitutional means. This state of mind, if widespread, is a very real danger. It may become the precursor of bolshevism and red revolution. The greatest safeguard, if not the only effective safeguard, against it is widespread social, economic, and ethical education.

He who hopes to confine the waters of a perennial stream courts disaster. The springs of social energy and change are inexhaustible. The wisest course is to recognize social aspirations and tendencies, to aim to give them intelligent direction by universal and thoroughly democratic education, and to afford them an adequate means of rational development and expression by efficient, democratic organization. This holds true in every field of social activity, inclusive of industry. It is the method that will secure the most real and rapid progress.

The democratization of industry is not more a matter of expediency than a moral necessity. The moral failure of the autocratic method in industry is shown by the hopeless divergence of view of capital and labor

generally. The nation that leaped to its feet as champion of the great cause of world freedom, as soon as conscience so decreed, even though every historical tradition might be violated by the decision, will, I feel confident, never permit questions of business tradition or of economic selfishness prevent her from championing the cause of democracy in industry, when once she is convinced of its justice, its righteousness, and its practicability. Its practicability rests mainly on an intelligent adaptation of the general education of all citizens to this end. The progress of democracy is indeed almost entirely an educational problem.

Industry sustains the life of every civilized human being. It lies thus at the very foundation of every other human activity. We degrade industry when we regard it solely or mainly as a means of private gain. Participation in industry is social service of the very highest order, since no other social service is possible without it. When this view is widely and clearly grasped and when it becomes an actuating motive to industrial activity, industry will attain to the position of real dignity proper to it—the dignity that is now generally conceded only to the pursuit of pure science. It will never be possible to engender a spirit of loyal coöperation between capital and labor in industry with nothing nobler to inspire it than the low motive of private gain. A widespread unity of spirit cannot be fostered without a great and worthy ideal. If we hope to reunite society by bonds of common selfish interests, we are doomed to disappointment. Only mutual service unites; selfishness disintegrates. The honor that is supposed to hold together a band of thieves is mutual service while it lasts, but it seldom withstands for long the disintegrating selfishness of their deeper nature. The inspiring unity begotten by a noble and worthy ideal was never more convincingly shown than by the alacrity of the response of every class in America to the call for defense of world freedom. No threatened suffering, loss, or danger was a sufficient deterrent to hold men back in the presence of this great and noble ideal. Suitable organization for effecting perfect coöperation quickly resulted. But an attempted organization without the great central, unselfish purpose would have effected nothing. It is primarily not a question of form but of spirit.

This ideal, that industry is social service of the most fundamental nature and therefore of the highest order, by no means precludes the incentive of intelligent self-interest. Neither did the ideal of world freedom. If closely regarded, both will be seen rather to include than to exclude the highest self-interest. The moral universe is fortunately so constituted that the highest self-interest is always best served by considering the welfare of our fellow men. "He that saveth his life shall lose it." Selfishness is self-defeating. Unselfishness is the only efficient selfishness. The highest attainable industrial efficiency, which we are all striving after, must ultimately rest on this moral

foundation of social service. This will be its ideal, and its method will be democracy and a "square deal." The nation that successfully and widely inculcates this ideal will lay a sure foundation of high individual as well as national efficiency and prosperity. The intelligent rooting in the minds of the oncoming generation of this higher economic ideal of industry as social service and the upbuilding of the less selfish character necessary to bring it increasingly into practical effect afford the greatest educational opportunity today.

In an address before the College and High School Department of the Ontario Educational Association last April, in a slightly different connection, I expressed this view in these words:

"Society already has before it a mass of unsolved social problems some of which we have broadly outlined, and of which none exists of more fundamental importance to the welfare of all than the antagonism between Capital and Labor. This problem, I believe, can be solved only by applying the democratic principle to industrial relations. The Anglo-Saxon struggle for democratic freedom has continued for more than seven centuries. It will not finally be won until the autocracy of capital is uprooted in industry. But the economic understanding, the ethical feeling and determination, the mental attitude—the indispensable psychological condition for getting together and viewing industry as a joint undertaking—must exist on the side of both Capital and Labor, before democratic organization for working amicably together can accomplish any good results. The idea must precede the expression; so must the psychological condition precede the organization. Hence we must aim to instil the truly democratic spirit of intelligent coöperation and social service in all, through our educational institutions, which citizens must rely upon to guide and quicken our social evolution in the manner outlined."

If we attach so much importance to the formation, by every educational means at our disposal, of sound economic and ethical ideas and ideals, in the minds of all oncoming citizens, why, it may be asked, do we further attach so much importance to the democratic form of organization as a means of solving the deadlock between capital and labor? Long experience, which has indeed culminated in the recent world calamity, has shown that autocratic rule in any sphere of life gives birth to ill-will, want of confidence, jealousy, and selfish ambitions. The secrecy of its methods creates the stifling and murky atmosphere in which spring up, as in a hot-bed, injustice, deception, suspicion, and distrust. This does not deny that the autocratic form of rule, in both the industrial and the political fields, has produced many results that, in outward appearance at least, were praiseworthy. But autocratic rule cannot safely be estimated at its face value. It has proved rotten at the heart. Superficially regarded, it may have appeared brilliantly successful, but it has

proved itself a whited sepulchre. It talked peace but secretly plotted war. It preached "kultur" but attempted by sudden onslaught to wreck civilization and nearly succeeded in its fell purpose. Its much vaunted efficiency was only apparent. It was purely material. It failed at the very core. It failed to develop human personality and character. The world today stands aghast at the full revelation of its human, or rather, inhuman, product. Can we honestly deny that this indictment of political autocracy applies in some degree to the autocratic form of organization in industry? Does it not appear to be working similar havoc? Distrust, suspicion, and antagonism are widespread. The democratic form of organization gives the best assurance of any method which human society has so far discovered of the kind of open-and-above-board treatment and the "square deal" on which alone confidence and good-will can rest. Thorough organization must exist in either case. The difference lies in the origin of the authority and in the consequent responsibility.

A question that deeply concerns us as engineers, managers, or superintendents of industrial enterprises is that of efficiency. In this matter, I fear, we have much blame to accept for narrowness of view. Because of our special training in the material sciences and their application to industry, we have confined our attention altogether too exclusively to machines, to processes, to arrangement of plants, and to the external forms of organization. We have paid far too little attention to the "imponderables"—to ethical standards, to psychological conditions, and to the mental attitude of those on whom real efficiency must finally depend. Surely it must be apparent to every one that there cannot be any approach to the highest attainable efficiency in production if there exists a general atmosphere of suspicion, distrust, and antagonism. Opposing forces tend to cancel one another. A high resultant can be obtained only by paralleling both the mental and the physical forces at work. Complete and efficient coöperation of the various factors in industry can be obtained only in an atmosphere of confidence and good-will. Efficient means of open discussion, knowledge of sound economic and ethical principles, and sterling character are essential prerequisites of confidence and good-will, hence also of high efficiency.

Industry has so far been under highly centralized rule. In this government, capital and management have had predominating sway. Labor has had little or no share. We are, I believe, at the threshold of self-government, or the application of the democratic principle to industry. We all need economic and ethical preparation for the more complex responsibilities this will cause to rest on us. Many old ideas and ideals regarding industry and business in general will find their way to the scrap heap. In the change, not only industry but we ourselves will rise to a new dignity. Industry will become more worthy of the best efforts of

all. In a new sense it will become the servant of the community and the handmaid of human well-being, in place of being largely a source of private gain and a cause of friction and conflict between opposing classes of society. It will thus come not only efficiently to supply the physical needs but also to minister to the high moral and spiritual purposes of human life. In this new government, all interested parties, not omitting labor, the largest party, will have a voice. On this continent the entire machinery of industrial self-government has yet to be worked out but it will probably be, as in England, of such a nature as to embrace existing, even though at present antagonistic, organizations. This safe method of building brick by brick on the foundation of existing institutions and experience is characteristic of the Anglo-Saxon genius for at once securing progress and avoiding revolution. In our study of this problem during the next few years, it will well repay us to give careful attention to the working out of the Whitley scheme in Great Britain.

English-speaking peoples have been foremost in the development of democratic political government, which they have recently joined hands in defending. Let us hope they are destined now to lead the world in applying the same principle to industry. This, if carried out on a basis of high economic and ethical ideals, as indeed it must be if it is successfully to be carried out at all, will make future war impossible. With the overthrow of Prussian despotism, the fight for freedom is only half over. Political and industrial autocracy may exist peacefully side by side; but political democracy and industrial autocracy, never. We may still have a long and difficult task ahead, but the job begun in Europe must be completed at home. The seeds of social and international conflict are inherent in the present system of industrial organization, which rests on the self-disintegrating foundation of human selfishness instead of on the solid rock of social service and human welfare. The awful suffering and carnage in Europe will not have been in vain if, after it all and in some measure as a result of it, human society has successfully started reconstruction on this new industrial foundation, which, if intelligently and diligently built upon, will gradually bring conditions of permanent, social, and international peace. In the great war, the soldiers of America, Great Britain, and their allies have shown the most indomitable courage. Have we now the moral courage to look squarely at and deeply into this industrial problem and, if convinced of the soundness and justice of this method of working out the solution of it, to continue at home the courageous stand for democracy which our brave fellows have so valiantly taken in Europe?

It is the Nemesis of autocratic rule that the greater its apparent success, the greater and the more certain is its ultimate downfall. If the world war has impressed on us any one lesson more clearly than another, it is this: that no human social structure, however imposing

in appearance or however brilliant in apparent success, can be permanent unless it is founded on the eternal principles of justice and right. If the principles herein discussed measure up to this standard, then, if we are really seeking a permanent solution of the great industrial problem, rather than a makeshift, we must seek to apply them. Industry will not in any case become fully democratized today or tomorrow, or even in the near future. But, if we do not mis-read the meaning of present social movements of world-wide extent, progress in this direction is as irresistible as the tides. To prolong opposition to it is to risk being overwhelmed by the flood. The wise and sensible course is for society to recognize its own movement, to undertake the most careful study of the economic and ethical conditions giving rise to it, and to arrange as quickly as may be for widespread social training of its members, in preparation for such utilization of these new powers as may result in the greatest justice and benefit to all.

One of the most encouraging signs of the times is the steadily increasing amount of time in our technical societies and of space in our technical and other more serious journals given to a discussion of the economic, social, and ethical aspects of industry. Let these discussions increase in both volume and earnestness and let this good work be backed as quickly and as strongly as possible by training the rising generation under our general educational systems, from common school to university, modified and adapted to meet the social exigencies of the times.

Discussion

S. J. Jennings, New York.—I had hoped to accentuate, and possibly emphasize from another angle, the real fundamental idea embodied in Mr. Corless' paper and trust that at some future occasion, when time is more auspicious, I will be enabled to bring before you my angle of views of the progress in the industrial relation that has been voiced by Mr. Corless. One of the things that I want you to think about and if possible bring up in some future discussion, is the idea that seems to be running through all of Mr. Corless' paper, that the world should be made "safe for democracy," that democracy is the salvation of the world. Now, that is all right if, after the world has been made safe for democracy, democracy is made safe for the world; and the only means of making democracy safe for the world is to educate the people who form the democracy. A sovereign has been defined as "A person or determinate body of persons who commands the rest of the community who are habituated to obey." Now, if democracy is all of the people, and therefore all the people are sovereigns, their command must be so based upon a clear conception of what they ought to be that they will be

naturally obeyed by the community; and the only method that human beings have so far discovered of doing that is by education.

In my opinion, one of the lessons that this war has brought clearly to us is the necessity in education of some military knowledge. An American colonel who had just returned from the front objected to this opinion, saying, "To teach a boy to be a soldier is to teach him to be a murderer. One of the main things that I taught my men in this war was how to cut the throat of an opponent with a fork. I do not want my son to be taught that thing." It seemed to me that he missed entirely the point of view, which was this: That while a soldier is an organized murderer, that is his end and aim, there are factors in his education that seem to be absolutely essential; these are obedience, discipline, and the knowledge of things rather than the knowledge of words. Those are the points I would like you to think about and I hope that in some of our meetings in the future they will be greatly discussed, that the progress that is outlined and visualized by Mr. Corless, which in his hope and in his vision is a great step forward toward the solution of the difficulties between capital, labor, managements and the community, will be solved.

The English-speaking Peoples*

BY T. A. RICKARD,† SAN FRANCISCO, CALIF.

(New York Meeting, February, 1919)

WE rejoice that the world-war is ended. We are proud of the part played by the English-speaking peoples—all doing equal honor to the traditions they share in common. One of the compensations for the calamity of the past four years is the fact that the Briton and the American, striving together in the cause of human liberty, have learned to understand and to respect each other. The mother country entered the fight resolutely at the beginning, while yet unready to meet the carefully prepared onslaught of the enemy; then the sons from the overseas dominions rallied to the old battle-cry eagerly and effectively; and last, but not least, the stepsons came from across the Atlantic, speaking the same speech, playing the same game, and fighting in the same clean way.

It was a great foregathering of those that use the language of Shakespeare and idealize the principles of liberty for which the friends and associates of Shakespeare stood sponsor three centuries ago.[1] At a time like this it is pleasant to dwell upon the fact that the liberal Englishmen who organized the Virginia company were the pioneers of self-government on the American continent. The Virginia Assembly, convoked in 1619, was the first example of a domestic parliament to regulate internal affairs on this side of the Atlantic.[2] The Governor of Virginia, Sir Edwin Sandys, had been a pupil of Richard Hooker at Oxford and from that political teacher he and his friends had imbibed the idea of combining civil liberty with constitutional order. To this group of large-minded Englishmen, the American colonists owed their liberal charters and their successive triumphs over the royal prerogative. Let it be noted that the American colonists had to deal with James II and George III, the two smallest minds in the list of British kings. Another historical note more pleasant to record, is the connection between the two principal groups of American settlers. In 1608 when the Pilgrim fathers, William Brewster and John Robinson, led their Separatist congregation to Holland and there prepared the expedition to America, they were assisted by Sandys and the Virginia Council, who were willing to share their privileges with them. When the Pilgrims set sail in 1620 they had the promise, obtained by Sandys from King James, that they should have freedom of worship,

* Presented at the joint session with the Canadian Mining Institute.

† Editor, *Mining and Scientific Press.*

[1] Charles Mills Gayley: "Shakespeare and the Founders of Liberty in America," 1917.

[2] Alexander Brown: "English Politics in Early Virginia History."

equality before the law, and the right to participate in the government of themselves. Thus the men whom we may regard as the friends of Shakespeare aided the founders of New England. Together they resisted the King's arbitrary dictation. "The political principles that inspired . . . that noble company never died out of Virginia, never died out of the northern colony, called New England. These were the principles first logically developed and clearly formulated by the tutor of Sir Edwin Sandys, Richard Hooker. Disciples of Hooker, associates of Shakespeare, were the founders of the first republics in the New World."[3] These political doctrines of Hooker not only inspired the founders of the first English settlements in America but found an echo in the minds of the men who led the Revolution and subscribed to the Declaration of Independence. Hooker's ideas passed to John Locke, and through him to Benjamin Franklin, Patrick Henry, and Thomas Jefferson.

It seems worth while to make this point insistently. The old Fourth of July talk is out of date, because it is historically untrue. George III was born of German parents and married a German woman. He spoke Shakespeare's language with a guttural accent. His government failed to impose its tyrannic orders on the British colonists in America because it was not supported by the British people. Unable to conscript a British army, he hired the Hessians. It was against the forces of a reactionary German king that a great Englishman, George Washington, led his men to the winning of their independence. Lafayette and Rochambeau brought French aid to the revolutionists, but their help was prompted less by love of the colonists than by the desire to hit at England, which was then at war with France. It was the despotism of Louis XVI that sent Rochambeau and his 6000 Frenchmen "to deal England a blow where she would feel it." That was in 1780. Permit me to remind you that only 18 years afterward, in 1798, the young United States was at war with France. This is not mentioned out of ill-will, but as a historic fact of some significance. We need not belittle the romance of the Lafayette episode, even though it has been highly colored, because it is helping today to stimulate cordiality between the United States and France, but we may demur to the twisting of history in order to represent the English people as reactionary and the French people as liberal at the time of the American revolution. As one who holds that "every man has two countries, his own and France;" as one that held this view even in the days of Fashoda, I venture to say that the friendship now existing between the United States and France is all to the good, because England and France likewise are firm friends. Their *entente cordiale* joins with French-American sympathy in establishing a mutuality of good-will between the three great democracies of the world.

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[3] Gayley: *Op. cit.*, 93.

It remains to emphasize another fact, to which allusion has been made already, namely, that the English striving for political freedom prepared the way alike for American and for French democracy. Locke, whose doctrines fed the fires of the English revolution of 1688 and those of the American revolution of 1775, derived his ideas of constitutional liberty from his fellow-countryman Hooker. It was Locke's theory that was embodied in the American Declaration of Independence in 1776 and that rationalized the French Declaration of the Rights of Man in 1789. Rousseau exercised no influence on the America of 1776; on the contrary, it was from English philosophers and from Anglo-American reformers that the French revolution derived its cue. English liberalism, disciplined by centuries of conflict, from the Magna Charta to the Bill of Rights, was the political mother of democratic institutions in the free commonwealths of the world.

Much of the prejudice against England inherited by children in the United States is due to the unfriendly tradition perpetuated in their school-books. Great Britain did treat the colonists shabbily after they had broken away from the old country, and, as the history of this nation is concerned chiefly with those early events, it is not surprising that the young American should be impressed much more by the overbearing attitude of Lord North's government, which was not so very different from that of most governments in those days, than by the shabby treatment given, in turn, to the loyalists in the American colonies. The so-called War of 1812 was bound to loom large in the school-histories, because it was the first contest following the achievement of American independence; but it was a tempest in a teapot; on land it was badly fought on both sides, although at sea the young American proved himself a chip of the old block; it was a side-show started in the midst of England's great contest with Napoleonic France. At that time England had a navy many times bigger than the American, and Wellington had just returned home from his victorious Peninsular campaign at the head of 100,000 veterans—a big army in those days. In 1814 Napoleon had been defeated, yet it was Wellington that made himself responsible for an honorable peace with the United States. It must be remembered that to the United States the Revolution was the very beginning of things; to England it was only one incident in a long and eventful history. "The game was played, and she had lost. North America, in the eyes of her statesmen, was a strip of eastern seaboard; the great lakes were but dimly understood; the continent beyond the Mississippi was ignored."[4] Therefore the Revolution and the little war of 1812 left no such sting in the minds of the British as the memories that were cherished on this side of the Atlantic. It is worth noting that in 1788 the first English settlement was made in Australia,

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[4] F. S. Oliver: "Alexander Hamilton," 115.

at Paramatta, in New South Wales. Thus Australia was added to the British dominions at the time of the American secession.

Another thought follows: looking back, it is probable that if England had been minded to recover the American colonies during the early period of their independence, she could have done so; but she had no mind to do so, and any Hanoverian king or government that had tried it would have had to face a revolution at home. Moreover, it is quite certain that the United States would have seceded sooner or later, because no government in Europe could have hoped to retain control over the growing giant of the West. I am frank to add that the idea of filling the United States with Englishmen is as unwelcome to my taste as the idea of peopling the British Isles with Americans. Variety is the spice of life.

> "Our dearest bond is this,
> Not like to like, but like in difference,
> Distinct in individualities."

Let us hope that the school-room histories in America will be rewritten in a spirit less unfriendly to the mother country. It may be more than a coincidence that the names of some of the publishers should be, for example, Kruger, Koch, and Lemp. When a New Englander or a son of Old England hears Germans, Irish, and Finns talking loudly about the time when "We licked the British in 1812," he may be pardoned for smiling. There were more Germans and Irish on the reactionary side in 1812 than on the liberal side. An acquaintance of mine, an Austrian Jew, the editor of a Jewish paper in San Francisco, began to tell me about the time when "*We* licked the British," whereupon I called a halt and asked him *qu'allait-il faire dans cette gallère?* I informed him that I had ancestors on both sides of that affair, at a time when his progenitors were wandering in the morasses of Eastern Europe without even a knowledge of the fact that the British were having a family quarrel. The foregoing story is capped by the statement appearing in a pamphlet prepared by the Sinn Feiners and intended for propaganda among the American soldiers stationed in Ireland. "We helped to win your independence," they assert.[5] The forefathers of this Republic may have had some outside help, but it is a little hard on them that they should be called upon at this late date to divide the honors with such as the Sinn Feiners! The people *they* helped were the Germans, not in 1776, but in 1917.

A couple of stories will illustrate this point further. During the Spanish war of 1898, I had as neighbors a man and his wife of British birth but of American citizenship. One day the man, in the presence of his son, a boy 12 years old, remarked that the United States would defeat Spain. Whereupon the boy exclaimed; "Lick Spain, well I guess we will. Why we licked *you* twice." That boy and his two brothers have fought

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[5] As recorded in dispatches published on January 11, 1918.

side by side with the British in France, one of them wearing the uniform of his father's native land because he could not wait until his own country entered the War.

Another boy's historical knowledge concerning the relations between the United States and Great Britain consisted of three items:

(1) Major Pitcairn spoke contemptuously of the revolutionists while he stirred his punch at Lexington.

(2) Andrew Jackson refused to black the dirty boots of a British tyrant.

(3) The Americans licked the English twice and would do it again for two cents.

Yet it is recorded that this same boy knocked down a perfectly well-behaved Bavarian in a barber-shop for expressing the opinion that England would be invaded. You could tell that boy all you pleased about the battle of Bunker Hill and the villainy of Lord North, but he would not forego his share of ownership in the Black Watch at Waterloo, of Nelson at Trafalgar, of Wolfe on the heights of Quebec, of Drake and the Golden Hind, or of the archers at Agincourt.

The tale of an ancient wrong should now be laid aside on a shelf beyond the reach of any but the most inquisitive student. The memory of Bunker Hill is overlaid by that of Manila bay. Let me recall the story as recorded by Dewey himself.

When Commodore Dewey drew the attention of Vice-Admiral von Diedrichs to the disproportion between the German naval force at Manila and the German interests in the Philippines,[6] he was met with: "I am here by order of the Kaiser, sir." The German admiral made trouble for the Americans continually, while maintaining the most cordial terms with the Spaniards; this also, it is to be presumed, by order of the Kaiser. He repeatedly ignored the blockade that Dewey had established after the battle of Manila bay, sending his warships into the harbor without allowing them to be boarded, as was necessary in order that they might be identified and assigned an anchorage. Dewey, in his autobiography, says: "Vice-Admiral von Diedrichs, in denial of the right, had notified us that he would submit the point to a conference of all the senior officers of the men-of-war in the harbor. But only one officer appeared, Captain Chichester, of the British 'Immortalité'. He informed the German commander that I was acting entirely within my right; that he had instructions from his government to comply with even more rigorous restrictions than I had laid down; and, moreover, that as senior British officer present he had passed the word that all British men-of-war upon entering the harbor should first report to me and fully satisfy any inquiries on my part before proceeding to the anchorage of the foreign fleet."[7]

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[6] "Autobiography of George Dewey, Admiral of the Navy," 257. 1913.

[7] *Op. cit.*, 266.

It is related by General Younghusband, of the British army, who was at Manila at the time, that when Von Diedrichs asked Chichester what he intended to do, the Englishman replied: "Just what Admiral Dewey and I have agreed upon."

A more significant incident occurred later, just before the town of Manila was captured, on May 13. I quote Dewey again: "As we got under way the officers and men of the British ship 'Immortalite' crowded on the deck, her guard was paraded, and her band played 'Under the Double Eagle,' which was known to be my favorite march. Then, as we drew away from the anchorage from which for over three months we had watched the city and bay, Captain Chichester got under way also and with the 'Immortalité' and the 'Iphigenia' steamed over toward the city and took up a position which placed his vessels between ours and those of the foreign fleet."[8] Thus the British warships were differentiated from the "foreign" fleet; they stood between Dewey and the Germans.

This was no mere idiosyncrasy of Chichester; it expressed the policy of the British government. In March, 1898, Germany asked England to join her and France in putting their fleets between Cuba and the American fleet. The British Foreign Secretary promptly refused. Great Britain was the one power that prevented the formation of a European coalition against the United States at the time of the war with Spain. It was then that the Kaiser exclaimed, "If I had a larger fleet I would take Uncle Sam by the scruff of the neck." More recently that part of his own anatomy has been in acute danger. On May 11, 1898, while the Spanish-American war was in progress, Joseph Chamberlain, the British. Secretary for Foreign Affairs, said in a speech at Birmingham:

"What is our next duty? It is to establish and to maintain bonds of permanent amity with our kinsmen across the Atlantic. There is a powerful and a generous nation. They speak our language. They are bred of our race. Their laws, their literature, their standpoint upon every question are the same as ours. Their feelings, their interests in the cause of humanity and the peaceful development of the world are identical with ours. I do not know what the future has in store for us; I do not know what arrangements may be possible with us; but this I do know and feel, that the closer, the more cordial, the fuller, and the more definite these arrangements are, with the consent of both peoples, the better it will be for both and for the world—and I even go so far as to say that, terrible as war may be, even war itself would be cheaply purchased if, in a great and noble cause, the Stars and Stripes and the Union Jack should wave together over an Anglo-Saxon alliance,"

Therein Chamberlain exhibited not only a brotherly spirit, but also the highest quality of statesmanship—foresight. His hope was fulfilled in 1918.

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[8] *Op. cit.*, 277.

The echoes of Yorktown and Saratoga are smothered by the glad shouts that come from Belleau Wood, Cambrai, Lille, and other recent battlefields on which the Union Jack and Old Glory were carried forward to victory. Then was fulfilled Jefferson's hope, as expressed in a letter to President Monroe, in 1824, advising him to accept the policy, now known as the Monroe Doctrine, which had been suggested by George Canning, Secretary of Foreign Affairs for Great Britain. Thomas Jefferson wrote: "Great Britain is the one nation which can do us the most harm of any one, or all on earth; and with her on our side we need not fear the whole world. With her, then, we should most sedulously cherish a cordial friendship, and nothing would tend more to knit our affections than to be fighting once more, side by side, in the same cause." That pious wish, so like Chamberlain's, has been splendidly fulfilled. Do you remember one of the flashes of history that we found in the day's news last October? It ran like this:

Somewhere on the Western front an assault was launched at dawn under cover of a creeping curtain of shell-fire. An American division advanced shouting "Lusitania." With them went a squadron of tanks. While this attack was progressing favorably a British division on the left swam the canal and pushed forward, in the face of scores of German machine-guns, to the village of Belleglise. By nine o'clock prisoners were being sent to the rear in droves. A pause followed this first phase of the battle. The Americans, tired but elated, stood in the trenches they had captured, while an Australian regiment, moving to their support, passed over them, or leap-frogged, to form the first wave of a new advance. The storm of cheering that greeted this manoeuvre rose high above the din of battle.

We echo those cheers today. The word "Lusitania" made those English-speaking soldiers a unit against

"A people with the heart of beasts
Made wise concerning men."

One fateful consequence of the War is the suicide of the German tradition. Before 1914 the Germans had a growing hold upon American business, they were grafting their kultur upon the American people, chiefly through the scheme of exchange-professors, whereby German propagandists were given a free hand at American universities, and, what was worse, sundry American professors went to Berlin, where they succumbed to the hospitality of the Kaiser and became sycophants to his purpose. The Germans were even obtaining success in imposing their language upon a large number of native-born Americans; and in doing this, they were undermining the English tradition, inherited legitimately from the founders of the United States. They were assisted in their propaganda by the fact that many Germans of the highest character

migrated to the United States at the time of the War of Liberation in 1848. These proved excellent American citizens because they came mostly from the South German States and brought with them none of the Prussian idea. They were followed in later years by other Germans, not so liberal-minded, but of undoubted capacity in business. Clannish always, they coöperated, they became pioneers of the German idea, which had made considerable headway when William of Hohenzollern and his military caste, supported by the German people, began their onslaught upon Western civilization. During the time the German tradition waxed in the United States that of the mother country waned; for many reasons, some large, others small. The American alienation from the people of "the sceptred isle" has been due in part to sympathy for those of "the emerald isle." Undoubtedly the blundering policy of the British government in handling the Irish question has tended to perpetuate the prejudice against England; the Irish are born politicians; in the big cities of this country they exert an influence far out of proportion to their numbers or their character; they have played into the hands of the Germans and together they have fostered a sentiment that has tended continually to hinder the development of good-will between our peoples. By "our peoples" I mean those represented by the Canadian Mining Institute and the American Institute of Mining Engineers. It has been the popular thing for generations in the United States "to twist the lion's tail;" it pleased both Irish and American prejudice; it was the regular stock-in-trade of frothy orators and jingo editors.

The English-speaking peoples have so many proud and happy memories in common that it is about time to balance the account. England did treat the colonists arbitrarily and they treated the loyalists shabbily; the young United States soon after achieving independence did have a further fuss with the mother country, which withdrew from the quarrel voluntarily. So much for that. From her independent sons in America England learned a lesson she has never forgotten, as is proved by the record of her relations with Canada, Australia, India, and Egypt, and her other territories, particularly her treatment of the Boers. She holds her overseas dominions by the silken thread of good-will, by that and nothing more. The American people share with the English people the glorious traditions derived from the men that helped to develop constitutional liberty before the Declaration of Independence, which was a logical sequel to the Magna Charta and the Bill of Rights. Many Americans, even those of British descent, may choose to forego the privilege of sharing those ancient glories, but they will not refuse to claim the inheritance of Chaucer and Spenser, of Shakespeare and Milton, of the King James version of the Bible and the Book of Common Prayer, of the English common law and the unwritten rules whereby both alike "play the game" in war and peace. For those traditions we are joint

trustees. To them we add now the vivid, the searing, the proud memories of the Great War, in which at last our men stood shoulder to shoulder to assert the principles of freedom on earth. Abraham Lincoln closed his first inaugural address by an appeal for reconciliation with the South; "The mystic chords of memory, stretching from every battlefield and patriot grave to every living heart and hearthstone all over this broad land, will yet swell the chorus of the Union, when again touched, as they surely will be, by the better angels of our nature." Does not this find an echo in our hearts today; do not the chords of our memory vibrate to the stories that have come from the battlefields in France, and will not the better angels of our nature play on those mystic chords a song to which we can pull together in unison for liberty, justice, and peace?

The visit of President Wilson to England, following our comradeship in arms during the War, is one of the great events of history. The intensely cordial greeting that he received during his visit, not only from King George but from the crowd, augurs well for the friendship between the English-speaking peoples. One of our miserable San Francisco papers spoke of the reception accorded to the President as the most enthusiastic ever given to "a foreign citizen," as if a man who found himself in a country where his native tongue is spoken, where his mother was born, and from which his paternal grandfather came, could feel himself a "foreigner." Legally he may be, but setting aside the legal fiction, Mr. Wilson found himself among his own kinsmen. There are three kinds of people in the world: Americans, Britons, and foreigners. Does any one of us feel like a foreigner when he is either in Canada, England, or the United States? I trow not. However, I have lived so long in the United States that I venture to warn Britons against over-playing the "kinsman" note. Mr. Wilson's ancestry brings him within the category, but most Americans do not like to be dubbed "kinsmen" or "cousins," because they are strongly assertive of their nationality, and of their own identity as a people; moreover, the influx of alien blood from the other countries of Europe is so considerable that it is incorrect to regard the American as a cousin of the Briton. Indeed, this assumption was at the bottom of much of the chagrin felt in Great Britain and in Canada when the Government of the United States deliberately adopted an attitude of neutrality during the early part of the War. Impatient as most of us may have been at the aloofness of the United States during that period, we should have reminded ourselves that the American people includes a large proportion of citizens of other than British descent, about one-half, of whom ten millions were born in Germany or born of German parents, and perhaps twice as many more have German ancestry. We ought to have reminded ourselves that even those who are of British descent feel their separateness strongly, partly on account of old revolutionary prejudice, and partly because there is

that constant urge to emphasize the individuality of the American nation. That is why I deem it more tactful, and also more in accord with the facts, to lay stress on our common notions of fair play and our common insistence on the right to live and let live—the right that the Prussian and his cohorts undertook to suppress. The Briton must accept the fact that the American, especially those Americans who have no English blood in their veins, dislikes an excess of emphasis on kinship. For instance, Theodore Roosevelt objected to it and he was a typical American if ever there was one. He had Dutch blood, English blood, French blood, even German blood, in his veins, but there is no mistaking the fact that in him it was no mere mechanical mixture but an ethnical compound, called "American," because it is entirely different from any of the ingredients of which it is composed. As he himself said: "We are a new and distinct nationality. We are developing our own distinctive culture and civilization, and the worth of this civilization will largely depend upon our determination to keep it distinctively our own." That undoubtedly is the voice of young America, the expression of the virile nationalism that Roosevelt typified so splendidly. If the call of the blood were to be taken literally, the cries from America to Europe would be as confused as those that arose from the Tower of Babel. President Poincaré at the opening of the Peace Conference said appropriately: "America, the daughter of Europe, crossed the ocean to rescue her mother from thraldom and to save civilization." Therefore, it is wiser to base our international friendship upon the other common factors: language, literature, law, sports, ideas, and ideals, themselves largely a consequence of our common ancestry.

Our people are different in their traditions and in their outlook, or, to be more nearly correct, the Briton cares more for tradition than the American, who, on the other hand, cares more for outlook. The one feels his background, the other his foreground. The Englishman accepts his social environment; he is proud that his father and grandfather did as he is doing; he loves the continuity of custom. The aim of the American is social extrication; he sees no reason for following in the footsteps of his forebears; he blazes a fresh trail, and rejoices in breaking into a new environment. Britain is politically a democracy, but socially she still preserves many of the traditions of feudal days. These make for the amenities of life, but they, and the social manners derived from them, are distasteful to the unconventional men and women of a country that has broken definitely with all that such customs imply. To us, "the rank is but the guinea-stamp; the man's the gold for all that." In freeing ourselves from such trappings we may have gone to the other extreme; the lack of respect for authority is not the most desirable trait of the democrat.

Life is full of compensations; every loss has some gain. The engaging

frankness of the American contrasts with the starving of emotion in the Englishman. He thinks it good form to suppress any expression of enthusiasm to the point of making himself appear cold or supercilious. It is an unlovely trait and destroys the natural grace of an intelligent human being. In England the religion of "good form" is a disease among well-bred men, making spontaneity a mark of the socially uneducated. An American officer says to a British officer: "Well, I guess we'll have to clean up the Boches together!" The English officer, adjusting his eye-glass, says, "Really." That reply was not meant to be insulting, but it chilled any *rapprochement*. We are reminded thereby of "a certain condescension among foreigners," on which an American essayist expatiated. May I suggest that some of that British superciliousness is due to shyness, not to impertinence; it is what our French friends call *mauvaise honte;* it springs from the Englishman's inbred fear of making himself ridiculous. On the other hand, the autobiographical garrulity of an opposite kind of American and the boyish inquisitiveness with which he will dive into the affairs of a comparative stranger bear the marks of a crudity that may sometimes be repellant. Again, an Englishman will be severely critical of his own country, because to him to speak well of her is like speaking well of himself, which is taboo, whereas the American will sail in boyishly to praise his native country and to assert how superior it is to every other. Such small national differences should be taken with good humor. The social code of a small island 3000 miles away does not fit the less formal, more spontaneous, life of a younger people sprawling across a continent more than 3000 miles wide. The American ought to understand the Briton if anybody is to do so, and, conversely, the Briton ought to meet the American half-way quicker than anybody else. Our mannerisms may be different, but our ideals are much the same. I am reminded of the story told of the judges who were preparing a congratulatory address for presentation to Queen Victoria, on the occasion of her jubilee. They were discussing the phrase "conscious as we are of our many infirmities," whereupon Bowen, the Master of the Rolls, suggested that the wording should be changed to "conscious as we are of each other's many infirmities." That, I regret to think, is what we do internationally. We are too much like the old man who said to his wife: "Everybody is queer except thee and me, and sometimes I think thee's a bit off." We need more tolerance—a more tolerant humor—remembering that a friend is a man whom you know well and still like. Britons and Americans can risk the closer acquaintance that leads to friendship, because they have fewer divergencies than common aims; and their friendship will be on a safer footing if they take each other as they are and determine to make the best of their interesting differences.

Let us look forward instead of backward. Whatever our differences

in the past, let us realize the similarity of our aims, the identity of our political ideals, and endeavor so to act and speak that the harvest of this calamitous war shall be not the barren thistle of discord but the wholesome wheat of good-will. The great sacrifices entailed by the War will be inadequately compensated if the result is not to establish closer relations of friendship between Britain and America. Indeed, it would be an immeasurable loss if the peace settlement should provoke any discord between the two English-speaking peoples. If we cannot agree to keep the peace, nay more, to work for human progress together, then no league of nations is conceivable that will do so. On the contrary, if there be any hope that mankind will advance not only from a jungle existence but from the organized vendetta of a semi-civilized state of society, if there be any hope of improvement in national relations, then that hope lies in one fact —a fact of which we have common reason for being intensely proud— and that is the 3500 miles of unfortified frontier between Canada and the United States. If we can live on such terms, with a willingness not only to arbitrate international differences but with a constant desire not to provoke them, then other nations—in time, all the nations of the world— will find it desirable, will find it imperative, to do the same. Let that physical frontier, without the menace of a fort, without the provocation of a single cannon, let it be the symbol of unaggressive neighborliness, of a mutual goodwill, of a promise of that "far off divine event"—of universal peace and amity—"to which the whole creation moves."

International Coöperation in Mining in North America*

BY A. R. LEDOUX,† NEW YORK

(New York Meeting, February, 1919)

I WAS wondering whether we were going to adhere to our text. It seems to me that we are having a very remarkable meeting of mining engineers this year, because no matter what the texts may be that are assigned to us, we get back toward something higher; we turn to the consideration of questions of ethics, and of applied Christianity. Yesterday we listened to the most eloquent and remarkable address by Mr. Rickard in memory of Dr. Raymond, and it was told us that he was to speak about Raymond's achievements as an engineer. He did say considerable on that subject, but he was himself carried away with the spirit of the man and moved us all by his portrayal of Dr. Raymond's continued and fruitful labors for the betterment of mankind—that is to say his religion.

Our President asked me if I would say something this afternoon and I find in the bulletin that the text of the discourses which we are to have here this afternoon is "International Coöperation in Mining in North America." But again I find that the eloquent speaker who has just preceded me has dwelt largely on ethical and spiritual coöperation rather than upon coöperation in mining. That is, coöperation as men, rather than solely as engineers.

The imaginary line dividing Canada from the United States, unmarked by fort or military post, was mentioned by a previous speaker. There are going to be in the future, I am sure, fewer entanglements of the barbed wire of tariff discrimination along our border—to that end let us coöperate. But there has always been a reciprocity in men. A Canadian conceived and created our great transcontinental line, the Great Northern Railway; an American made the Canadian Pacific what it is.

In mining and metallurgy, American engineers, backed by American capital, have built up great Canadian industries while Canadian experts have developed some of the resources on this side of the line. They have done much more than develop our resources: some of them have been our leaders in sympathy for labor. It is therefore not a question of creating a spirit of coöperation, but of giving it freer scope and a fuller realization of fraternity—or, to use the word now more common and of deeper significance—brotherhood.

These are days of combination. Corporate interests in this country are now compelled, or at least encouraged, to combine in ways that

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† Mining Engineer and Assayer.

would have landed their directors in jail, if attempted a few years ago. The Sherman law is still on our statute books, but so are some of the "blue laws" of New England—more honored in their breach than in their observance.

The friendly relations, growing even closer, between the two great Mining Institutes, point the way to increasing coöperation. We have much to learn from Canada. I venture to suggest that if some of the distinguished Canadians, our guests today, could be given an opportunity to tell the solons in Washington wherein Canadian mining laws are an improvement on those still prevailing on this side of the boundary, it would be of real service, for they would be disinterested witnesses. There are precedents for this: Some of us have been asked to appear before committees of the Dominion and Provincial Parliaments of Canada to give evidence and advice on laws proposed for the control or assistance of mining and metallurgical industries.

It is for those more actively engaged than I in mining to tell how best we may advance the interests of the industry, which is alone surpassed in importance by that of agriculture in Canada and the United States. Can we not appoint in each Institute permanent committees on coöperation that will hold frequent joint sessions, and make suggestions to their respective societies leading to action that may benefit us all?

I suppose "North America" in the title was intended to include Mexico. What chance is there to coöperate in that land of chaos and revolution? Personally, I think there will be such opportunity in the near future. The Mexican is a proud man; his complaint that foreigners alone have exploited and profited from the resources of his country is to some extent justified. But some of our mining companies operating in Mexico have employed and still employ Mexicans in positions of trust and authority, with satisfaction. When the time comes for the United States to consider and to act upon questions of rehabilitation of railroads, mining and other industries, in which so much foreign money has been lost, and to propose safeguards for the future, we shall have to decide, as in the Philippines, whether it will be easier to "civilize 'em with a Krag" as militarists proposed, or to suggest a Joint Commission of foreign and Mexican composition, as in our far-eastern dependency. This is a question—this one of policy—that is soon to come to the front; it is one on which there are differences of opinion.

Mr. Chairman, I have purposely injected this Mexican problem into this meeting, that if there be time it may be discussed, and that our two Institutes may perhaps become pioneers in influencing public opinion. To this task, our Canadian brethren can bring more open minds; they are farther away from the disturbance and can better understand both sides.

DISCUSSION

S. J. JENNINGS, New York.—I am sure we all appreciate Dr. Ledoux's suggestion that a permanent committee should be appointed by both the American Institute of Mining and Metallurgical Engineers and the Canadian Mining Institute, in order to suggest closer and more constant coöperation. This suggestion will undoubtedly be brought before the Directors of the American Institute of Mining and Metallurgical Engineers and I trust that the Canadian Institute will also take it into account and have a committee appointed, that will serve with that spirit of closer coöperation, that idea of common ancestry, which has so eloquently been placed before us this afternoon.

Dr. Ledoux's suggestion of coöperation with Mexico is one that is extremely close to my mind. I am planning to go to Mexico the end of this week and hope to meet with a local session in the City of Mexico soon after my arrival there. We may then initiate some discussion of the problems that confront the American engineer, or the members of the American Institute of Mining Engineers located in America, whether he be an American, or Mexican, and ventilate those problems so that we will appreciate his ideas and help solve them.

Uniform Mining Law for North America*

BY T. E. GODSON,† OTTAWA, ONT.

(New York Meeting, February, 1919)

As this is the age of reform, a uniform mining law for North America is a moot subject for discussion at this meeting of the Institute. The question is one of peculiarly technical and, in many respects, local character. We all appreciate the value of the metal-producing industries and recognize the necessity and importance of a well-considered and evenly balanced mining law as a branch of our jurisprudence either for the Provinces or the Dominion as a whole.

Mining has taken its place as a foremost industry and legislation that seeks to control and govern it is the concern of not only the active miner but the citizens of the state. A law that, through its charitable measures brings into being the prospector, the pathfinder and superstructure of all mining activity and industry, protects his interests, safeguards invested capital, and encourages and enforces development, possesses at least the salient requirements of a businesslike Act. The manner of doing so is, I think, one of local and internal concern.

May I be permitted to say without presumption that of the five mining codes, or Acts, that we have in the Dominion of Canada born and bred within the Provinces of British Columbia, Ontario, Quebec, New Brunswick, and Nova Scotia, some of them could be materially improved. In many respects they do not measure up to the times; they were no doubt creations of merit at the date of their birth but they have not been clothed in seasonable raiment as the years passed by.

It is a stern fundamental principle that all natural resources are the inalienable property of the crown. If it is mineral land, then it follows for the protection of the state and the direct advancement of the occupant that the land should be developed as such. The method or machinery by which this must be accomplished is a matter of detail, not of principle. If the right to possession as a licensee depends on discovery, it is not inconsistent with the duty the crown owes to the state that a grant in fee should pass to the discoverer if there is imposed, after patent issues, a requirement of continuous work or the alternative of an acreage tax sufficiently burdensome to make it unprofitable that the land should be held in an undeveloped state. If this requirement is recognized, the mental distinction between a grant and lease ceases to exist. A

* Presented at the joint session with the Canadian Mining Institute.

† K. C., Mining Commissioner.

grant contingent upon work or payment of taxes is not dissimilar in effect to a lease upon terms. In my opinion it is a matter of indifference which method is adopted provided title is dependent on development. Capital will follow mineral and should be willing to accept a leasehold tenure, provided the conditions of the lease are fixed and unalterable and the term of occupation is sufficiently long to permit proper development and a reasonable return for money invested.

From time to time spasmodic attempts are made in Canada to assimilate various Provincial laws. We have demanded a Dominion Commercial Code, a common Bankruptcy Law, and a uniform Companies Act, but they are yet to come into being. Nearly all the Provinces of Canada have a Workmens' Compensation Act, but these laws differ in essentials if not, in some respects, in principle. Public sentiment favors a systematized, assimilated, and uniform law upon a given subject when possible. Then why the necessity for a uniform mining law for North America? I prefer to discuss it from its applicability to Canada. I do not know what suggested the discussion. Is it to be said a real necessity has arisen: if so what is the foundation of the complaint? Is it not rather that discussion has been invited upon this broad and comprehensive subject in order that the attention of the Provincial Legislatures within Canada and its Federal Parliament and the Federal authorities of the United States of America may awaken to the knocking hand of opportunity and so frame their laws that the opportunity is not allowed to pass by unheeded? Each Province should know best its own requirements. A fundamental change in a law recognized, adopted, and followed for years should not, in my opinion, be made unless imperative; but the foundation of a particular law or act, if sound, should be built upon and extended to meet all economic changes, and it is just there our respective mining laws need attention.

If one is to be guided by the silence of comment, the Mining Act of the Province of Ontario might be said to be satisfactory; but that it can be improved is admitted. We have progressed and prospered under a discovery clause, harsh and stern in its requirements, but it will be said the law has not been observed, probably not since inspection has been done away with, but the clause has served a good and useful purpose.

The principle of discovery I believe to be absolutely sound, the difficulty is its application; but that opens up too broad a field to discuss at this time. If you remove the prerequisite of discovery you must tighten the strings of control in the crown's hands after patent.

Development is a condition of possession and should be a fundamental principle underlying all mining law. The right to a claim should only exist as long as it is worked or taxed to insure work. Once depart from that sound maxim, there results improper control of the natural resources of the country, which primarily belong to the people. A requi-

site of discovery at some period prior to a grant with the imposition of an acreage tax after patent of an amount that will prevent inaction is sufficient justification for a crown grant as adopted in Ontario.

It is the retention of public control, not necessarily revenue, that should govern in fixing the amount of the tax. The tax must be consistent with the rights of the prospector, who is entitled to the fruits of his labor, and must not offend capital, which is sensitive.

The point of view of the Provinces of Manitoba, Saskatchewan, and Alberta when they obtain their natural resources is problematical. Are they to be guided by our own experience in the adoption of an Act, or by what appears to be essential to the building up of a mining industry within their Provinces? Prospectors must be encouraged; capital must be coaxed and flirted with. How best can this be done is their problem not ours; and this suggests one of the many difficulties of a common mining law for the whole Dominion.

We feel that we have an Act which meets and encourages the prospector, welcomes the capitalists, and promotes the development of our mineral resources. What has been and is being done is evidence of this fact. Each year, it is sought, by material changes in the Act, to meet conditions as they arise. We have yet to sit in final judgment upon the present use and future necessity of a discovery clause, but that will be dealt with when the question has been thoroughly canvassed.

Under our Act, if certain requirements are not performed within the time required by the Act, an *ipso facto* forfeiture occurs; but that forfeiture may be relieved against by an application to the Mining Commissioner within 3 months from default. If no adverse interests have arisen, usually the application is granted. If new interests have appeared, it is a question for compensation if the application is to be allowed. There is a further provision allowing an application, after 3 months from default, to go to the Lieutenant-Governor in Council upon the recommendation of the Minister and report of the Commissioners; this salient provision is not extensively used but it has met many cases of merit where a serious loss would have occurred if there had been no relieving section. It will be observed that the Minister is protected by the condition requiring a report to be filed by the Commissioner based upon evidence heard *viva voce*, or otherwise, as is deemed expedient.

The office of Mining Commissioner is a creation of the Mining Act of Ontario and provides machinery not to be found in other Acts. It is judicial in its nature, with right of appeal from the decision of the Commissioner to the Appellate Court in the same manner an appeal is carried from a trial judge to that Court. Disputes, notices of claim of interests prior to patent, applications for relief from forfeiture, and all litigious matters come before the Commissioner. The procedure is simple and unencumbered by pleadings with the happy result that litigation is

cheapened and expedited and there is no undue delay in determining the issue such as necessarily occurs in the congestion of our civil courts. As it is a moving court, the Commissioner has the advantage of hearing the point of view of many of the prospectors with regard to the working of the Act. This close contact has the natural tendency of keeping the Act in step with public opinion. Another salutary provision of our Act is the right given to the Commissioner, where required in connection with the proper working of a mine, mill for treating ore, or quarry, after hearing the interested parties to vest in the owner lessee or holder the right to discharge water upon any land, to draw off or divert, collect or dam back water and to take the same, rights of way over other lands, to enter upon and use specified areas and to deposit tailings, slimes, etc., all of which power must not be exercised unless any wrong or damage caused to any other person can be adequately compensated for nor unless it is reasonable and fitting to grant the same. This section, if used advisedly, greatly promotes mining and prevents selfish and antagonistic interests from defeating a legitimate mining enterprise.

I have touched upon some of the features of our Act for the purpose of showing that they are outstanding and are a step in advance of any other Act I have read and if there is to be (and I would welcome it) a uniform Act for Canada or North America I say, from experience and with due modesty, that our Act in many respects might be used as a pattern.

Let there be a general awakening to our necessities. If nothing more is accomplished than a remodeling of the different mining laws of the respective Provinces, time and discussion will have been well spent. If each Province is to retain its own creation, it should be put in concise readable form so that "he who runs may read." At present, it strains the ingenuity of a lawyer to grasp the requirements of some of the Acts. This is the result of inattention and want of due consideration in their formation.

BY H. V. WINCHELL,* MINNEAPOLIS, MINN.

It seems to me that uniformity of mining law in North America, must of necessity start with uniformity in each country. I understand that the Provinces of Canada have the right to make their own individual laws and conditions, to prescribe the terms under which the prospector or the applicant for mineral titles may secure the same. That is not true of the states in the United States. In this country, the Federal Mining Law was made applicable to the public domain, which, at the time of the adoption of this Act in 1872, was chiefly west of the Missouri River; it is impossible to locate a mining claim in most of our eastern states. It is true, however, that there are certain holdover rights, mostly obsolete,

* President, American Institute of Mining and Metallurgical Engineers for 1919–20.

arising from the fact that at the time of the formation of the Confederation of States, the land that belonged to each state became the property of the Federal Government. I am not quite correct in that, it was sometime after the adoption of our Constitution, I think it was 1778, but those rights were largely, by agreement, surrendered to the Federal Government; but it is a fact that the great acquisitions of territory in the West, with the single exception of Texas, were of domain that came into the possession of the Federal Government and our Federal Mining Law applies to that territory. No state has the right to (by legislative enactment) enlarge upon the rights given by the Federal Mining Law, governing the acquisition of mining claims in its territory, within its boundaries. Each state however may, and some of them do, limit somewhat the rights given to the prospector. For instance, the Federal Mining Law provides that a claim may be taken, staked upon the public domain, of 600 ft. in width and 1500 ft. in length. Some of the states, like South Dakota and Colorado, have at times said that is an excessive amount of land for a single mining claim; we will therefore limit it to 300 ft. or 200 ft. in width. There is, therefore, not any direct and immediate need for uniformity of mining laws in the United States, such as there might possibly be if it were considered at all desirable upon the whole in Canada.

The initiation of mining rights under the Federal Mining Act is the act of discovery of valuable mineral in place, referring now to the lode mining claims, but the same is true of the placer claim. It is true that the emphasis has never been laid upon the word valuable and that for a long time there was such a vast surplus, or an excessive amount of unwanted, undesirable land in the West that the land offices did not scrutinize the claim sought to be located. They passed upon it perfunctorily and granted the patents upon affidavits of the owner. As a result it became customary to allow a prospector to locate a claim or any number of claims, and to do a certain amount of work each year; then after filing his affidavit for assessment work and going through the preliminaries and paying the required purchase price he would secure his patent. It is a fact, however, that mineral must be discovered. The right to the enjoyment of possession is based upon that fundamental fact; if a contest arises, before patent, and it is shown by the contesting applicant that there was a defect or an untruth in the statement of the discovery of mineral, such a claim may be canceled.

We recognize very many points of excellence in the Canadian mining laws and particularly in that of Ontario. We have for a long time felt that our law is woefully defective in some respects. There is, however, apparently a fundamental difference of principle as to the character of title to mineral land between that of the United States and that of Ontario. The United States law grants the title to a piece of ground together with all veins or lodes whose outcrops or apices lie within the exterior bounda-

ries of the claim granted, although upon their descent into the earth, such veins depart from a perpendicular and pass beneath the surface of the property of an adjoining claim.

It is probably true that there is still a vestige of the regalian right in our mining law; it is perhaps true that by no act of Congress nor any specific general rule, has the fundamental and inherent sovereignty, sovereign ownership, of the right to minerals, the ownership of minerals ever been alienated by the United States. The situation is somewhat similar to that in some of the British Provinces, where the first or some early charter conveyed or authorized the conveyance of titles to all of the land with the underlying minerals. Such was the case in South Australia where, for seventeen years, grants were made of lands, together with the minerals, under the full authority of the acts of Parliament. When minerals were discovered, the then Governor-General said, "Minerals belong to the crown, we will take possession and charge a royalty, and so on." The owners of lands protested and said, "But you cannot do that, it has all been threshed out, we have our patents, we have them under authority of the Acts of Parliament." The Governor-General replied, "Nevertheless, minerals belong to the crown." Upon appeal to the higher authority, it was decided, I understand, that no Governor-General and no sovereign could alienate from himself, the inherent right and title to those minerals.

The Government, therefore, resumed possession and occupation; but in the true English, generous, equitable fashion said to the owners of this mining grant, "Now we have given you that land and taken away your minerals, but we will return your royalty minus expenses." We have never attempted, so far as I know, to thoroughly test out that question. The courts have held that if in the government grant there is no reservation of mineral (not referring now to a mining claim but to a homestead, a ranch, anything of that sort) the grant conveys also subterranean rights to everything beneath the area of the surface conveyed. Recently, there has arisen litigation over the construction of railroad grants in the West and an effort has been made in some cases to get the government to reclaim the oil and other minerals beneath the surface of lands that were conveyed without a mineral reservation. It is probable that in the United States, therefore, under a long line of decisions, that the title to the minerals beneath the surface, where the land has been conveyed in some other form than as mining land, will not be attacked.

The custom of locating square claims with cardinal boundaries, on the latitude and longitude parallels and meridians, is one that appeals to a good many of us in this country. We should be very glad, indeed, I think, to see a modification in our laws as to permit some such arrangement as that. The mass of mining locations that are plastered over

some of the ground in our mining camps in the West is simply worse than any Chinese puzzle; and it leads to endless confusion and litigation.

Reverting to that question of discovery, it is my opinion (I am not in accord with all of the mining men of this country, as I well know), that under the new conditions with the new kinds of prospecting made possible by diamond drilling and other methods of exploration and the new developments of metallurgy, in which ore may be a rock containing an infinitesimal amount of value, the requirement for discovery is putting the cart before the horse. You say to the prospector, "You find the mine and we will let you prospect for it." Now, why not say, "Go out and stake a claim, and as long as you spend your money in good faith looking for minerals, you may hold it." Or, if you prefer, say, "Hunt for five years spending so much per acre, per annum, and if you do not find it, let somebody else have a chance." But the idea of requiring a mine to be discovered before the man has a mine seems, to me, ridiculous.

Of course, we have that very ingenious aid to mine litigation, the apex provision in our law, and it is not necessary to dwell upon that here. I certainly would not recommend its adoption in any uniform law to cover territory in Canada. I believe you had a little experience with it in British Columbia. We are the only people, with the single possible exception of Rhodesia, in Africa, where that extralateral right provision still lingers. We have found it difficult to convince our Congressmen of our sincerity in advocating its abolition, and the mining men have encountered considerable opposition on the part of Western Bar Associations, when they attempted to minimize the amount of litigation called for.

One thing that we have admired in the Ontario laws in general, is the fair treatment given to the owner, prospector, and the man endeavoring to develop mines. We have sometimes chafed a little under the regulations, perhaps, simply because they were a little different; we have not realized the importance of the limitation of the number of claims that a man can buy after the prospector has found something; and if a patent is issued and five cents an acre tax paid, if some person wishes to buy the claims that have been located by one hundred prospectors he can do it. The purpose of prospecting and mining laws is development of mineral resources. It seems to me the requirement for continuous development and work is the vital point and not limiting the number of claims that a man might take. One man might be able to work only three claims, another might work one hundred, but if the work went on and the mines were developed, that is the result desired.

I have always been impressed by the liberality and fairness of treatment received by the prospector and miner in Ontario and I am glad to have this occasion of saying so.

I should like to ask one question, I am not quite clear on that point: Do the laws of Ontario limit these prospector's licenses to citizens?

T. W. GIBSON.—A miner's license can be had by anybody. They are limited at the present time to those nations who were allied with us in the war. We would not give a German a license, of course.

MR. WINCHELL.—That is a more liberal provision than is contained in the United States mining law. An applicant for a mining claim in the United States must be a citizen of the United States or one who has declared his intention of becoming such. Of course that simply prevents some prospectors; it does not hinder a German or anybody else from buying a claim after it has been located, but there is that restriction. That fact was pointed out to me by an eminent attorney in Argentina, who said, "Down in Argentina anybody can take a mining claim, the United States has shut everybody out unless they are citizens, that is why our laws are better than yours." Well, it is true that provision is contained in one of the few opening paragraphs of their code, but it is not followed by the same liberality and simplicity of provision.

The Mexican mining law has been, I cannot speak from actual knowledge of what it is right now, a very good mining law. It has been possible to acquire a title to property, to operate with few restrictions, to pay a return to the government upon the material produced. In general, the mining law has been admirable. Of course, it was based upon the experience of a long time; it was in some respects built quite similar to the old Spanish code. There, however, again the government does not part with the title to the minerals. There is a little different system.

It seems to me, therefore, that when we consider the question of uniformity throughout North America, that uniformity would not be in every respect advisable. I believe, as Mr. Godson said, that conditions are so different, the character of the minerals in different countries are so different, the habits and customs and wants of the people are so different, that it is not altogether desirable. What is desirable, is a closer appreciation of each other's needs, and of the needs of the industry as a whole, better coöperation in development, in the exchange of ideas, in the exchange of commodities, and in freedom of access to information, and, as Dr. Ledoux said, possibly the exchange of materials, machinery, products, without tariff limitations.

DISCUSSION

H. H. ROWATT,* Ottawa, Canada.—One of the previous speakers spoke very fully about the Ontario mining law and the difference which exists between the law and the mining law of some of the other Provinces. The Federal Government administers the minerals in a portion of

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the Dominion of Canada; that is, the Government administers the minerals in those Provinces that were not originally included in the federation and which have been brought into confederation more recently. Manitoba, Saskatchewan, Alberta, and the unorganized northern territories are administered by the Federal Government; the minerals in these provinces and territories are also administered by that Government. Up to the year 1887, it was not thought that these western territories, then known as the Northwest Territories, contained any minerals. But coal has been discovered in several parts of the western territories. The precious metals have always been the property of the crown, but the baser were conveyed in fee-simple, issued for such rights in the form of homesteads and purchases. On Nov. 1, 1887, all mines and minerals were reserved to the crown, and all titles that were earned subsequent to that date contained a reservation of the minerals. Titles earned prior to that date reserved only gold and silver.

In the Western Provinces, there are minerals that are not found in Ontario and the mining law, as a result, is of a broader character, but this afternoon regulations that were particularly discussed, were the lode regulations and in these the Federal law differs only very slightly from the laws of the Province of Ontario. Up to the year 1914, these laws were practically similar; but by amendment to the Dominion's Land Act at that time the title was changed from fee-simple to lease, and all titles earned subsequent to that year are in the form of leases. But this lease is practically a perpetual lease; that is, it is issued for a period of 21 years and is renewable for an additional period. In nearly every respect, it is quite as good as the fee-simple.

I think that so far as regulations dealing with lode mining are concerned, there would be very little difficulty, indeed, so far as the Dominion of Canada is concerned to have a uniform mining law. There are only a few particulars in which the Federal mining law, in respect to lode mining, differs from the laws of the Provinces. There is, perhaps, a little more liberality in the Federal law, in that a prospector for minerals may stake claims and may acquire the final form of title. It is not necessary to be a British subject, it is only necessary to be a subject of a country that is not an alien-enemy country, in order to acquire all rights to minerals under Federal lands. Citizens of allied countries are entitled to precisely the same privileges as citizens of the British Empire, and I think that in nearly all of the Provinces of the Dominion, this law is the same; that is, that only persons of alien-enemy nationality are barred from acquiring licenses. That is the only regulation that has been discussed, and therefore I have confined my remarks to that regulation and from my knowledge of the American mining law, dealing with lode mining, there is a very great similarity in the laws of each country.

President Jennings.—I would like to call the attention of some

of the gentlemen, who may not be familiar with it, to the hardship caused by the necessity for discovery before the issuance of the right to prospect. In the state of Nicaragua, where the necessity for discovery prior to the issuance of a title obtains, there is a lode which outcrops for several thousand feet; it starts in with a dip of something like 60° and as it goes down, it changes its dip to about 40° and at a depth of less than 800 ft. dips out of the property which was originally available to locate the crop. The hanging wall of that lode is a siliceous material which, so far, has absolutely failed to reveal any other valuable mineral except that one vein, so you would have to sink a shaft at least 800 ft. deep through the hanging wall of that vein in order to get the deep levels of the property. While you know that valuable deposits exist there, you cannot discover it in the surface area which would be covered by the deep levels of that claim and therefore you cannot get them. That was brought to the attention of the Nicaragua Government and an attempt was made to persuade it to change the laws. The last I heard these laws had not been changed.

THOS. W. GIBSON, Toronto, Ont.—Discovery has been referred to as a matter of importance. That was and is a requirement of the Ontario law, and on one occasion a vigorous effort was made to enforce this requirement. In 1903, the first discoveries were made in what speedily proved to be one of the most valuable silver fields ever found—the Cobalt camp. Proof of discovery under the regulations was met by filing the affidavit of the discoverer. In many cases, especially near a known and valuable deposit, doubts were freely cast on the genuineness of the alleged discovery, and it was felt that an affidavit was not sufficient proof. Accordingly, a demand arose from the prospectors that all discoveries on the strength of which claims were staked should be inspected by the government, and passed on officially. Inspectors of known skill and probity were appointed for this purpose, and "passed" or canceled claims according to whether or not in their judgment, a real find had been made. The practice was to notify the locator, and have him accompany the inspector while the latter made his examination.

These silver veins were unusually valuable, containing up to 10,000 oz. of silver per ton of ore. Carloads of 25 or 30 tons were taken out and shipped, bringing as much as $100,000 or $120,000 in net returns, with silver at 60 c. per oz. or less. Possession of ground so rich was a prize worth striving for; consequently it is doubtful whether any other area of ground of equal size anywhere was ever more closely or minutely prospected than the Cobalt silver area. A prospector simply had to make a real discovery in order to obtain a valid claim. This plan was followed for several years, until in fact most of the outcropping veins has been located and staked. The sentiment of the prospectors changed; they said: If a man is willing to spend his time and money in trying to make

a mine out of any piece of ground, why not let him do so and give him the claim? The inspectors were accordingly withdrawn, and the system of inspecting discoveries discontinued.

Another point I wish to speak of is the mineral rights as apart from the surface rights. It used to be the case that in granting a piece of land for agricultural purposes, the mineral rights were reserved to the crown, and prospectors were permitted to go on privately owned land and look for minerals. If they made a find, they could secure the mineral rights, on due compensation being made to the land owner for damages to the surface. In case of dispute the matter was referred to the Mining Commissioner. That system was brought to an end about 11 years ago. It would not become me to say anything disrespectful of the law, but in the interest of mining it is doubtful whether the change was an improvement. Much of the land was taken up by farmers who are not prospectors and have little knowledge or interest in minerals, perhaps would not recognize valuable mineral if they saw it. The consequence is the land so granted has gone unprospected, because no prospector will spend his time looking for minerals on land if he cannot get the benefit of what he may find. There is a possibility of mineral deposits lying concealed on agricultural grants, which if located and worked would strengthen and expand the mining industry.

H. V. Winchell.—I have just one or two words appropriate to Mr. Gibson's remarks. I have called attention to the situation in writing. A few years hence our public domain will be no more. Where then is our prospector going to find scope for his activities? There is no provision in our law by which a prospector may go upon privately owned property and by compensating the owner for damage to surface, or in any other way have the right to prospect. Some day we are going to be face to face with the necessity for an amendment to the Federal Constitution, giving that right again to the government to say to the prospector, "You may go where you will and sink diamond-drill holes, or otherwise, upon lands that heretofore have been conveyed to private owners." It will be an absolute necessity to provide some such provision as that.

Now I wish to say further that our Land Department has within the last few years attempted to inspect the validity of discoveries to inquire into mining claims for which applications have been made. We have had a class of mineral examiners who have gone through the land looking at these things, not always in company with the applicant or the claimant, and reporting upon them. Some of them have been good men and some have not, but what difference did that make? How could a man go to Tonapa and decide upon the prospect of finding ore on a claim where the lava was 2000 ft. deep over the outcrop of the vein? How could he go to Utah copper mine and decide as to that whole mountain of material which occupies the surface, which is highly discolored in places, under-

neath which lies the largest copper-ore deposit being worked in the United States today? How could he go to Butte and look at the outcrop or look at the first 450 ft. of development work on the Anaconda Copper Mine and its veins, which in many cases do not carry one trace of copper, and in some cases only a trace of gold, and say it is going to be a copper mine. The opinion of no one is sufficient to say a prospector has a claim that is going to develop into a mine. He must have time to prospect it and develop it and that is the only thing.

PRESIDENT JENNINGS.—I would like to just add one word to this discussion on the point brought out by Mr. Gibson and that is when, as I understand it, land has once been allocated to a farmer, the present law in Ontario is that the minerals underneath that land go with it and therefore, also belong to the farmer. The question arises in his mind, and in that of Mr. Winchell also, how are you going to develop mines under these circumstances? That is what happened in the Transvaal. When a land passed to a farmer, a certain amount of the mineral rights passed with it, but while the state nominally reserved to itself the right of minerals, it granted at the same time the right to the farmer to say whether or not his land should be prospected. If he did not want it prospected, it was not, but if he did want it prospected and valuable minerals were found, he had for his own right a certain fraction of that farm, which was called the mynpact. A similar way of handling the situation, it seems to me, can easily enough arise in the United States. If I think that on any given man's farm or piece of ground there is a chance to discover mineral rights, I can go and agree with him and say: "If you will allow me to prospect on your land, I will do so under such and such terms. I will spend my money and my time in the chance of finding the mineral, and if I do find mineral, we will share in that mineral in any given proportion." This method was adopted in the Transvaal, and certainly that is one of the largest fields of mineral discoveries of the world. It looks to me that to inject a new principle in the ownership of land is not necessary. An agreement with the owner is always possible, and if not with that particular owner, when he dies, with his heir.

T. C. DENIS,* Quebec, Canada.—With reference to one of Mr. Gibson's arguments, I may say that the Province of Quebec adopted, in 1880, the principle of the separation of the mineral rights from the surface rights. On all crown lands granted to colonists for agricultural purposes, since 1880, the legislature reserves the mineral rights, and those holding prospecting licenses may go and prospect those lands for minerals. When the owner of the land objects to the prospector going on the land the prospector comes to our office and makes certain deposits, determined by the Mining Bureau, to guarantee against damages.

* Supt. of Mines, Province of Quebec.

In the province of Quebec on nearly all lands granted by the King of France before the conquest by England, the mineral rights were reserved and in the old settled parts of Quebec the government owns the mineral rights. We often have granted mineral claims on lands that were ceded to French seigniors back in the 17th century, and we really have had no trouble. Of course we have not had intensive mineral activities, our annual mineral production being around $16,000,000; but I do not think any trouble would arise from this condition.

A. R. CHAMBERS,* New Glasgow, N. S.—In the old colony of Newfoundland, the rights to all minerals are vested in the crown, and a mining man or prospector having placed his application with the crown, or more correctly, with the Mining Department, proceeds to prosecute either the prospecting or the mining, as the occasion demands, of any or all minerals that may be found thereon, and so he has complete authority to exercise all his ability and interest capital as well during the term of his mining right. There is here, possibly, a tendency to tie up a lot of mining lands without work being energetically carried on. But, in listening to this discussion, I have been wondering whether or not some compromise between these two ways would not be better. That is to say, if we have a claim in which we can get full right and title to all mineral, without the burden of previously proving the existence of the same, let it be so arranged that full advantage can be taken of this, with proper precautions of course to avoid non-working.

In Nova Scotia the situation is much more complicated. The crown has been giving surface grants for many years and some of the older grants gave nearly all minerals to the surface owners. But, as time passed, the crown reserved more and more minerals, until in 1858, practically all mining rights were reserved to the crown. In this field we have, as I say, a very complicated situation and, while I am not prepared to make any comment on it, the information given here this afternoon will, I know, help us in that country, for I fear we will have to do something in the near future to revise these laws.

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* Nova Scotia Steel & Coal Co.

Employment of Mine Labor

Discussion of the paper of H. M. WILSON, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 145, January, 1919, p. 83.

C. W. GOODALE,* Butte, Mont.—In regard to the employment manager, the North Butte Mining Co. has undertaken that line of work and the rest of the companies are watching the experiment. If it is proved to be the proper thing, the system will be introduced into other mines. We have to combat the opposition to the use of the "rustling" card. It is nothing more nor less than asking the nationality, where the man formerly worked, and whether he is married or single.

ROBERT RHEA GOODRICH, Anaconda, Mont. (written discussion†).—Since the efficiency of the different phases of personnel work employed by industrial concerns, which are bringing about greater efficiency and lessening the labor turnover, the latter being intimately connected with "contentment of mind," depends on the individual workman, it is highly desirable, as far as industry is concerned, to keep the workman's mind and body in trim in order to lessen accidents and produce a higher grade of work. Prevention being better than cure, health supervision of the workmen during employment should be maintained by the employers in order that mental alertness and physical well-being may be obtained. I have long believed, from observation in many plants, that when any problem is dependent on the individual workman, what he believes and what he does is vitally dependent on his health. I will follow with much interest what is to be done in the future in relation to the subject of health supervision during employment (as well as medical examinations at the time of employment), and I hope this idea will be generally instituted in personnel work.

A workman with good health and a contented mind should be an ideal component of a progressive industrial concern. The contentment of the workman is fostered by a number of admirable phases of welfare work which are being still further developed. The mental and physical well-being of labor should be the issue in Labor vs. Capital in the new period of the industrial promotion of the United States into which we are now entering.

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* Manager, B. & M. Dept., Anaconda Copper Mining Co.

† Received Feb. 17, 1919.

M. D. Cooper,* Brownsville, Pa.—In the bituminous mines the whole system at the present time, with a few notable exceptions, is lost in confusion. In fact, there is no system. At the average mine, the superintendent or foreman employs his men with very little examination of any kind, physical or mental. There is need, therefore, of some standardization of methods. This is accomplished, in the case of the larger mines, by an employment bureau, but in Western Pennsylvania there are a great many mines, employing from five up to 100 men, which are at a disadvantage when it comes to maintaining any sort of employment bureau. But it is possible to establish a system without an employment department; that is to say, some form of a record may be made of the men and their fitness for certain positions and this record passed about among the employees in the handling of the labor situation. A better method would be a coöperative employment bureau among the small employers.

The next feature of the employment of mine labor is that of retention. This, during the past two years, has been an exceedingly serious problem. Two factors affect the retention of mine labor: The first is the reputation of the employer. This is dependent largely on living conditions; that is the location of the plant, the character of the houses provided, sanitation, etc. Recreation is increasingly important. The company with which I am associated has recently attempted to solve the problem of recreation and add to the contentment of the community by erecting a community house, which contains a moving-picture show, bowling alleys, pool tables, etc. This is a move in the right direction. Education also is an important feature. The miners are much more interested than formerly in the educational facilities provided for their children. Next, after the reputation of the employer, is the conduct of the bosses in the company organization. It has been the constant effort of our company to obtain for the official positions men who were able to take a broad-minded view in regard to mine labor. This is not an easy thing to bring about, but on its accomplishment depends the success of the company in retaining men. In this connection the point Dr. Lanza has brought out in regard to the examination of men is very important. I suppose we can all think of men who are employed in certain positions where they are entirely out of place physically.

The third feature of employment of mine labor is that of disconnection with the company; there is vast room for improvement here. The solution of this problem lies in the giving of sufficient notice both by the laborer when he intends to quit and by the official when he intends to discharge the man.

The Chairman (B. F. Tillson,† Franklin, N. J.).—It seems to me that the employment of labor is so closely knit with the problem of

* Assistant General Manager, Hecla Coal & Coke Co., Pittsburgh, Pa.

† Mining Engineer, New Jersey Zinc Co.

labor turnover that it would be of great interest if our *Transactions* contained data, or figures, from representatives of various companies in regard to what their labor turnover has been during this past year. I may say that the zinc mine at Franklin had a labor turnover of 72 per cent. for the past year. Furthermore, the question of attendance enters importantly in production. If the attendance is poor and the foreman does not know on how many he can rely, it produces inefficiency. The attendance during the same period was 87.5 per cent. of the possible shifts of labor, which includes two months' suffering from the epidemic of influenza, which was very severe in the camp. The lack of attendance may be classified as follows: Loss of time due to accident, loss of time due to illness, loss of time from other causes, realizing that the loss of time due to illness is often brought about by inebriety. The corresponding statistics were for this same force of men, averaging about 850: Loss of time due to accident, 0.5 per cent. of the total possible time; loss of time due to claimed illness, 3 per cent.; loss of time from other causes, 9 per cent., which indicates that a man's lack of interest in earning more and attending to his job are an important factor in the amount of work being done by the present forces of labor.

E. A. Holbrook,* Urbana, Ill.—In listening to the remarks of the Chairman on labor turnover, the question arose in my mind, on what do we base our figures when computing our labor turnover? In one case, I was told, the labor turnover is figured on the basis of men working a month or more; in another place, the labor turnover is figured on the basis of a man going into his working place and putting in a shift; in another place, a man is simply put on the books of the company and is figured in the turnover. I would like to ask what is the basis on which you figure your labor turnover?

Chairman Tillson.—The labor turnover is based on the number of men leaving divided by the average possible number of men that might have been working during the year, and the average possible force is obtained by dividing the total possible number of labor shifts by the average number of working shifts during the year. We have studied the problems from many angles and it seems to be a well accepted conclusion that this is the proper rating of labor turnover.

James P. Munroe,† Washington, D. C.—May I say, in connection with the very interesting paper that Mr. Wilson has presented, that I bring very encouraging news from the city of Lawrence, where my factory is. Lawrence has a very mixed foreign population so the Bolsheviki have been concentrating on it as the opening place for their campaign. For many weeks they have been sending their best

*Supervising Mine Engineer and Metallurgist, U. S. Bureau of Mines.
†Vice-chairman, Federal Board for Vocational Education.

leaders into the city to head this outbreak; but the movement has petered out. The foreign people have taken no stock whatever in these doctrines, with the result that all these leaders have gone away disgusted, saying that it is absolutely impossible to make any progress.

Use of Cripples in Industry

Discussion of the paper of JAMES P. MUNROE, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 145, January, 1919, p. 87.

JAMES P. MUNROE.—The present situation is vastly different from the situation at the time the paper was written. We now know pretty well what our problem with the disabled soldier is: 50,000 disabled men have come back and the Surgeon General tells us that probably 35,000 more are coming over in the months of March and April. So the total number of disabled men will be 85,000, which of course includes a great number of slightly disabled. If we followed the proportion that obtains in other countries, we would have about 10 per cent. of those people to be retrained under the Vocational Law. As a matter of fact, the general intelligence of our men is so much higher and the provision the government has made for the training of these disabled men is so much more liberal than with the other governments that we feel very certain indeed that instead of having 8500 men to be retrained there will probably be twelve and possibly fifteen thousand.

Prevention of Illness Among Mine Employees

Discussion of the paper of A. J. LANZA, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 435.

J. J. CARRIGAN, Butte, Mont. (written discussion*).—I think all who have had experience in the operation of metal mines will agree with Dr. Lanza that many improvements can be made in the underground workings to improve health conditions. Physical examination would no doubt be a good thing and would do a great deal in abating the diseases now so common among metal miners, but I cannot see how it would be possible to put this examination into practical working order. Dr. Lanza says, "For the sake of argument, this physical examination should be under state supervision." I think if this were attempted it would result in nothing but argument. While such a law possibly could be passed in a few states, I feel certain that in the greater number the miners would fight such legislation with the same determination that they would

* Received Feb. 17, 1919.

fight a change of the working day from 8 to 10 hr. In the smaller mining camps this examination could probably be carried out under the supervision of the mining company with considerable success. In the large mining camps of the West that have adopted it, we all know how far it is from being satisfactory; it causes more discontent among the men than any other change of conditions that the companies may try to bring about.

Dry drilling, no doubt, has been one of the chief causes of tuberculosis among miners. While this practice is still being carried on to some extent, the reason for it is that there has been no wet drill that was at all satisfactory for use in all conditions of stoping. For some time, however, there has been on the market a spray used in connection with drilling that eliminates the dust in a satisfactory manner, but I know that 95 per cent. of the miners would refuse to use the spray and would sooner "eat the dust" than work under wet or muddy conditions.

The Anaconda company has been experimenting with a water stoper that, I think, will prove satisfactory. All the drill manufacturers have been working along these lines for some time, and probably the dry stoper drills will soon be entirely replaced by the wet drill.

Ventilation of metal mines is about the most important and one of the biggest problems to be considered, not only from a standpoint of improving health conditions, but as a matter of efficiency, but to compare the problems in the ventilation of coal mines with those of metal mines is hardly fair. The nature of the underground workings is entirely different, and the character of the ground in the metal mines is such that large amounts of timber are necessary, the oxidation of which generates a great deal of heat. By working on different levels in the metal mines the men are distributed over a large area, and there may be many different veins to be worked from each level, which makes it a great deal harder to control the air currents.

Until a few years ago, the mines in the camps of the West were operated by many small independent companies and the larger companies did not work together as they do now. Very little attention was paid to ventilation, at first, it not being necessary, and as the mines increased in depth, these independent companies were lax in matters of ventilation. Since these companies have been consolidated, it has required a great deal of work to improve conditions, owing to the condition of the old workings and to the different elevations of the levels.

The Anaconda company has been going into the ventilation question very thoroughly for some time and has an engineer in charge of this work. I think we all realize what a big job it is and that it will be some time before the ventilation conditions are as the company desires to have them.

Regarding toilet conditions underground, all the mines of the Anaconda company are equipped with sanitary toilet cars, which are taken to

the surface every day to be cleaned. I suppose that most of the companies in the country have similar equipment, as it is, no doubt, very important from a standpoint of health.

C. E. CALVERT, Butte, Mont. (written discussion*).—Dr. Lanza's suggestion of an inter-state medical examination will meet with considerable dissension. It is safe to say that 50 per cent. of the miners are migratory, working from one camp to another and covering territory from Alaska to Mexico. These miners would object very strenuously to medical examinations at every move, and yet a medical passport between states does not sound feasible.

A law compelling medical examination would necessarily require some standard of health, and this also would cause dissension. Suppose an applicant failed to pass this standard, his medical card would show this and he would immediately become an undesirable, from the standpoint of an efficient laborer. If unable to procure employment on account of his health, he would naturally seek retribution from his former employer and one can readily see the difficulties in store should such a proceeding be carried out.

It is agreed by all that dry drilling is one of the chief causes of chalicosis so prevalent among miners, yet this cause could be practically removed by proper legislation and strict enforcement of the law. Wet drilling in upper holes has not been developed because wet stoping machines have not proved entirely satisfactory. This lack of development by the companies may be attributed in part to the indifference of the miner. Had the miner demanded such a machine from the mining companies, they, in turn, would have demanded some improvement from the machinery companies. A few wet stopers have been tried in this locality but the personal element enters into the operation of the machine to such an extent that its success or failure depends on the individual miner.

C. W. GOODALE,† Butte, Mont.—A few years ago the miners had a law passed compelling the mine companies to furnish 100 ft. of free air per minute, exclusive of any air that was furnished from the air compresses, or the air used in drilling. At the present time the Anaconda company has machinery furnishing air at the rate of 300 cu. ft. per min. and it will soon be doubled, at the cost of $500,000.

THE CHAIRMAN (B. F. TILLSON,‡ Franklin, N. J.).—I would like to ask Dr. Lanza if he would qualify his statement in regard to all rock being injurious by including non-siliceous rock?

* Received Feb. 17, 1919.

† Manager, B. & M. Dept., Anaconda Copper Mining Co.

‡ Mining Engineer, New Jersey Zinc Co.

A. J. LANZA.—I should say that if it was pure limestone it would not be considered contributory to tuberculosis. I mentioned hard rock. Some lime rock is siliceous and is injurious.

CHAIRMAN TILLSON.—Might I ask also whether that includes coal dust?

A. J. LANZA.—The question of coal dust is a very interesting one and is not entirely settled. There is considerable evidence to show that the coal miner is relatively immune to tuberculosis, and some very interesting views and arguments and demonstrations have been worked out by anatomists and pathologists as to why it is that a man who accumulates coal dust in his lungs is immune to tuberculosis. There is, however, I understand a growing notion that the dust may not be as harmless as supposed and I recently came in contact with men who complained bitterly of coke dust; but I have had no opportunity of finding out if it was doing them any harm. They complained that it was.

H. M. WILSON,* Pittsburgh, Pa.—Is it not possible that the immunity of coal miners to tuberculosis is due to the well known fact that one of the greatest preventatives and curatives of tuberculosis is the oxygen that comes from open-air life and plenty of fresh air; and therefore may not this immunity be due to the fact that in coal mines there is generally good ventilation and plenty of fresh air blown into the mine, and the men working in the mine are actually living under better conditions of good oxygen to breathe than the men in almost any other occupation that I know of?

A. J. LANZA.—I do not think that that is at all tenable. There is no getting around the fact that the inhalation of coal dust causes very marked changes in the structure of the lung, and it is also a well known fact that the process of producing fibrous tissue is an offset to tuberculosis, as it does not afford a very advantageous ground for the development of the tuberculosis bacillus. As far as we can see, that is the only explanation that will hold water as to why coal miners are relatively immune to tuberculosis.

I want to say another word about dry drilling and about the remarks I made about dry drilling. I know perfectly well that the water drill was invented a good many years ago and have seen various water stopers and water drills and the like and all of us have seen water sprays in use on drills and we know these latter are totally worthless. There never was a water spray affixed to a drill that was worth the time and trouble it took to put it in place. There is only one kind of water drill that will be any good and that is a drill where water has to be used for the drill to function properly. We know that there are good water drills yet the dry drills are used in great numbers. There is absolutely no reason for that practice

* Director of Department of Inspection and Safety, The Associated Companies.

and you are not going to have anything but tuberculous miners while it is continued. There are all kinds of laws to prevent dry drilling; it is a question of enforcing the law. The point I want to make is this: dry drilling is practised to an inexcusable extent and I think the American Institute of Mining Engineers could very well take some steps to eliminate such practice.

Need for Vocational Schools in Mining Communities

Discussion of the paper of J. C. WRIGHT, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 145, January, 1919, p. 91.

J. C. WRIGHT.—The problem of organizing and maintaining a vocational class for those employees who are engaged in the mining industry depends on several most important factors. The first is the sympathetic coöperation of employer and employee; the second is to find the subject matter that must be presented to these men; and the third is to find the instructor who can present that subject matter. This is perhaps the most difficult, for we usually find a man who knows the material that is to be presented but is not a teacher or does not know how to organize his material. The man must know the subject matter from the standpoint of absolute contact with industry in order to be a successful teacher.

I have come into contact with two kinds of schools organized in connection with mining occupations. In one type the instruction leans very largely toward elementary subjects, arithmetic, reading and writing and spelling; it is not of such a character as to help or improve the working man in his occupation in the sense that we are attempting when we speak of vocational education. In the other type of school, an engineer is usually employed as a teacher. He immediately begins to give the things with which he is most familiar and the instruction becomes such as only those who possess a high-school or college education, perhaps, are able to receive. In between these two schools is the school we are trying to promote, a school that will meet the needs of those employed.

MARGUERITE W. JORDAN,* Altoona, Pa.—Vocational education has become the business man's problem; for he is the keeper of that white elephant, labor turnover, and anything that will decrease the size of the monster is worthy of serious consideration. This vocational education can do;-for it can supply many of those deficiencies in upbringing and environment that make for the discontent and restlessness of our varied classes of unskilled labor: the Anglo-Saxon mountaineer; the Southern negroes who have crossed Mason & Dixon's line by the thousands, "searching satisfaction for our minds;" and the still greater number who have sought across the sea America, "the promised land."

*Advisory Council, Industrial Relations.

For no one is this question of discontented labor more acute than for the coal operator, especially because the mining industry, by its very nature, offers unattractive home environment. The timber has been largely stripped and many of the streams look like liquid coal. Huge waste heaps, barren hills, grimy red and gray houses help to make a landscape that is monotonous and dreary. Working away from the sunlight is not particularly conducive to mental or moral advancement. Add to this the lonesomeness of the job, time to think and little to think about but grievances, and the fact that the element of danger is always present. Is it any wonder that the miner returns at night, gloomy and irritable, to his unsightly home and half-cooked meal?

Here at once vocational education can remedy much, with its domestic-science courses. The oldest of the world's arts, home-making, is still strangely new to the vast majority of those who assume life's gravest responsibility without the least training. Contrary to the average man's opinion on the subject, women are not born knowing how to sew or cook. We catch influenza and other things, but we do not catch home-making. If the wife of the wage earner knows anything about it, it is because her mother knew; and if that mother was a peasant of Southern Europe, a mountaineer, or a cotton field "nigger," her chances are slim. It is usually almost as much a matter of individual discovery as if she were living on a desert island, but when eggs are 80c. a dozen, Robinson Crusoe stuff comes pretty high. The ordinary domestic-science course of the public school offers little aid to this condition, for familiarity with electric equipment and white marble-top tables gives one no sense of poise when she meets a kitchen equipment consisting solely of a two-eyed coal stove and a frying pan.

Nor are the public schools much more adequate in developing general intelligence. In a recent issue of *Coal Age* I read this: "Let the teachers be instructed by mine officials, to maintain a high standard of order and cleanliness in the school." But what of the fact that 350,000 of our teachers are less than 19 years old; that two-thirds of these have not completed the eighth grade; that a large majority of these are teaching in mining villages, where "them shoes" and "has saw" is good school English? Moreover, we pay the average school teacher less than a day laborer. Our national chewing-gum bill is larger than our educational bill. Can the coal operators look for community improvement through such instruction? Yet children at the rate of a million a year are leaving these schools to enter industry, children with practically untrained minds. Naturally, the child and the industry can profit in only a small degree from the instruction of the foreman.

Industry suffers, too, because our schools fail to realize that learning to work and working can become an affair of absorbing interest. Disregard of this work instinct of the child—which is first expressed in play,

visualized and acted from the local industries—means abnormal and curtailed development; and this is the beginning of our misfits, unfits, the lame ducks of industry. In contrast to this there is the story of a little girl in one of the mountain schools who had a job of making beds. One day she was not feeling very well and was told that unless she felt much better she need not get up in the morning.

"Oh," she said, "I'm aimin' to be stirrin' soon; hit's Saturday, and I wouldn't trust anybody else to put clean sheets on the beds."

As far as my limited experience in industry is concerned, that spirit of responsibility is the thing mine owners are in greatest need of; and, contrary to former opinions, we have learned that it won't "just grow." This very spirit is a product of vocational education.

There is excellent precedent for vocational education. In 1642, parents and masters were warned "to give their workers training in employments which would be profitable to themselves and to the Commonwealth." England now demands 8 hr. per week of vocational training for all workers under 18, as well as for unskilled employees above that age. This is done on company time, and in this way will England maintain its supply of skilled labor. France, also, has compulsory training in all shops. Our own vocational schools demonstrated their possibilities by training thousands of army mechanics in a short time. Many of America's industries have adopted vocational work, and the Smith-Hughes Act makes it possible in all industries.

Other things being equal, a man of the mines is the ideal teacher, and if he is man enough for the job, the difficulties will iron out. When a person is hired for the work, it ought to be understood that it is not a "two hours a night" job, but a job to which is to be given all the time necessary to do a good piece of work. The school needs an executive head, with time for organization, and one with an understanding of community, individual, and industrial needs. Just as in any business, there must be care used as to its establishment, and such a job cannot be wished on the already over-busy school superintendent.

The vocational school is in reality a business and must take the point of view that if it is going to do business it must adopt aggressive methods of advertising. Of primary importance is the necessity of presenting the work solely from the standpoint of utility. The fact that 50,000 men have enrolled in mining courses of correspondence schools shows the demand when the value is understood. The time and interest of a miner is limited, and the work must be so organized that he can easily get what he needs. The experienced workers have judgment based on first-hand knowledge; they know by experience what the trade demands of them and what are their deficiencies; they know what things are assets and what things are not. For this reason the courses for experienced and inexperienced workers differ. Classes should be grouped according

to age as well as mental capacity. The evening schools in the British Empire were a failure for years largely through the grouping of men and young boys in the same class. There cannot be the ordinary school standards. The entrance qualification is fitness to profit by trade instruction.

The guiding thought to be held throughout the course is the necessity of making the man do the maximum amount of thinking to meet a present, not a future, need; for he will not submit to a preparatory drill. Therefore, the necessity for the short unit course. For instance, to automobile mechanics a course could be given in five lessons in testing and experimenting on lubrication. Such a short course compels direct and intensive training; thus the effort of the pupil is concentrated upon one subject and not dissipated among several. The result is more regular attendance, more intensive work, and a corresponding gain in efficiency. Of course, there can be several short unit courses, arranged in sequence, each giving its own certificate. The knowledge of a definite accomplishment is a greater incentive, and the state examinations are another.

Textbooks are difficult, largely because "they ain't none;" the bulletins furnished by the Bureau of Mines are possibly the best. Due to greatly varied conditions, it would be unwise to map out a standard course. A careful study of the equipment available, both in schools and in private establishments, often reveals unexpected sources of supply and will determine the courses that can be given to advantage.

Labor is the largest cost factor in nearly all kinds of production. We know, for instance, that to maintain a force of 1000 men costs annually from $100,000 to $200,000. Therefore, it is obviously even wiser to improve our labor than it is to improve our machinery. It is on this basis that vocational education can be justified as a corporate activity. The Federal Board comes forth with a very liberal offer of aid; yet it does not propose to dictate to the operator what sort of training shall be given to his miners. It specifically states that no sort of training will be forced upon him. He himself will define the training to be given, by simply stating which of his needs he cannot provide for by any system of shop training.

The average employer in the United States has accepted without question the general proposition that he has nothing to contribute to educational work. He has looked upon schooling, together with the professional schoolman, as something set apart from real life. Now, however, is his opportunity to make a contribution of very real value to education. The methods of vocational education are being developed; the mine owner is asked not to sit back and wait for the vocational school product to come and then find out that it is not what is needed. The producer (the school) and the consumer (the employer) must get

together now, in the formative period, and agree on the kind of training needed and how it can best be given; then encourage the boys to take the school training by giving them a chance to make good. It is discouraging for a boy who has given several years to a course of training in a trade school to start on the same level as a boy from the street, who has had no training whatever. Do not sidestep by saying, "If he is any good he will come up to the top." He may, if he has a chance and is not lost in your organization. If the school is any good, encourage those who take the training by recognizing its value when they come to you for employment. If it is not what it ought to be, take an active interest in it and help make it what it should be. It will pay in satisfaction and in dollars and cents, for it will give the student a distinct advantage in the market. Success is conditioned upon the development of a degree of efficiency equal to, if not surpassing, the degree attained by competitors. Do the mine owners of America want to utilize this fund for improving the efficiency of their own employees, or shall the Federal appropriation be turned back into the Treasury as not wanted?

It has been said that there is hardly a kind of agony on the modern battlefield that has not its counterpart somewhere in our economic struggle. Can we not face this struggle in the same high spirit with which we faced the struggle of arms? While it is true that the war released the lowest and grossest traits of humanity, it also tapped wellsprings of spiritual strength, of idealism, of self-sacrifice, of service and devotion at which cynics and pessimists and criminal minds of the world have stood aghast. Are we to lose all this because the war is over? The value of coöperation has been demonstrated as never before; the twentieth century has made us into a brotherhood; and the very industrial relations that offer exasperating chances for misunderstanding, discord and collision, offer also noble opportunities for that greatest of undertakings, the upbuilding of humanity.

E. A. Holbrook,* Washington, D. C. (written discussion†).—My purpose in discussing this paper is to emphasize to the members of this Institute the fundamental and far-reaching changes in the present ideas of training miners, which this nation-wide plan of vocational education soon will put into effect. Any mining company, knowingly or unknowingly, is under considerable and constant expense in breaking in new men. Today every man going underground for the first time must learn from haphazard contact and chance, little by little, the duties of his vocation and how best to guard himself against the peculiar dangers and conditions underground. The army has shown what it is possible to do in the way of concentrated training of a group of men in any chosen vocation. When vocational schools are established in every important

*Acting Chief Mining Engineer, U. S. Bureau of Mines. †Received Feb. 17, 1919.

mining community, it will mean a uniformly high standard of knowledge of his duties by every man who calls himself a miner.

In mining communities in the United States, efforts in vocational educational lines have heretofore often been isolated, irregular, and confined to a few of the largest mining communities, or carried into effect by a few of the larger mining companies. Often, the man employed as teacher has been chosen for his qualifications as a school man, and with minimum regard for his ability and practice in the vocation he teaches. In some cases there has been an effort to make a partly trained engineer of the student, rather than a first-class craftsman at his trade. In other cases, universities and states have, or are working on, first-class standards of vocational education. Considering the great extent of the mining industry, and the inadequate sums of money hitherto allotted for the purpose of vocational education, the efforts have not reached the great body of miners in every state, which is now possible under Federal supervision and aid.

Consider the problem from a purely economic viewpoint. Our mines are every day getting deeper and larger, and machinery is constantly replacing hand labor. These improvements in mechanical and electrical appliances have increased the complexity of the trades belonging to the mining industry and necessitated a greater knowledge in the workers. On the other hand, this introduction of machinery means that we are no longer wholly dependent for manual labor on the skilled American miner and the immigrant from Britain and the north of Europe, who in many cases come from families who have been miners for generations. Of the Scotch, English, and Irish miners in this country, 92 per cent. were miners in the old country. The use of machinery has enabled men to gain employment in mines as loaders for mining machines and in other underground occupations, whose only qualification is that of a laborer. Thus, the last 20 years has seen a tremendous influx of south Europeans into our mining industry. These men have had no experience in mining, generally having been agricultural laborers; for example, only 3.6 per cent. of the Lithuanian and 7.3 per cent. of the Russian miners in this country had previous mining experience.[1] The employment of these men underground must ever be a menace.

Mining is a hazardous occupation. Mr. Wright states that the dangers in coal mining are greater than in metal mining. Although this is the generally accepted idea, a study of the accident statistics of the Bureau of Mines reveals that for the last 7 years, 1911 to 1917 inclusive, of about 700,000 men engaged in coal mining 3.38 per thousand employed were killed each year; in the metal mines during the same period, of about

[1]Statistics from the Study of the Immigration Commission in 1910; an exhaustive report, which includes the immigrant in the mining industry.

175,000 men engaged, 3.79 per thousand per year were killed. Statistics compiled from the report of the mine inspector of Pennsylvania for the years 1915 and 1916 combined show that the miner of so-called south-European races was, in proportion to the number engaged, nearly twice as liable to meet with fatal accident as the native and foreign miner of the English-speaking races. If education in his vocation were to put this man on a level of skill equal to his more fortunate brother, there would be a great saving to the mining companies of many millions of dollars spent in compensation insurance, in the cost of hiring and firing men, and in increased efficiency of the workmen. In addition to this financial saving, there would be a tremendous gain to the country on account of the good-will, contentment and loyalty gained by Americanization of the foreign miner.

The work of the various mining companies in having elaborate safety organizations and in conducting safety propaganda, which appeal to the eye and ear of the miner, and the work of the Bureau of Mines in promoting safety measures, must be considered partial expedients looking to the time when fundamental education in the trades shall make the man of the new generation more skillful than the present, both in his work and in handling himself underground. It must be, then, to the interest of every mining company to actively help this vocational work through the introductory stages.

Mental Tests in Industry

Discussion of the paper presented by MAJOR ROBERT M. YERKES at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 405.

B. F. TILLSON,* Franklin Furnace, N. J.—I would like to ask Major Yerkes if he will not give us more examples of the tests than are contained in the printed pamphlet. It would be of great interest to study them more carefully.

ROBERT M. YERKES, Washington, D. C.—The reason for not reproducing the methods in any public print is that it lessens their value and necessitates the preparation of new test materials.

BRADLEY STOUGHTON, New York, N. Y.—I hope that this matter will be of so much interest to the members of the Institute that the Directors will decide to appoint a committee which can bring further results of this practice before us. I understand that Columbia University, at least in some departments, has already adopted the B and A tests and is using them. I understand that some industries have considered seriously the question of grading their employees in accordance with

*Mining Engineer, New Jersey Zinc Co.

some mental tests. If that is to prove of value, the quicker the mining engineers and metallurgists are familiar with the proper people to carry on the work or the proper methods to be employed, the better. We generally work through committees, as you know, and I hope one may be established.

One thing that interested me was the high rating of the engineers and I questioned whether these mental tests were not rather more easy for engineers than for men of other vocations, although of equal intelligence. Engineers naturally are trained to mental impulse and that I believe is one of the characteristics of the different tests. I noted in particular that the telegraphers had a large number of high-grade men and a very small number of low-grade mental individuals. It occurred to me that also might have something to do with the occupation of the telegraphers. Any of you who have played with telegraphy know how instantly the application of an idea must follow the slightest variation, the ticking must be recorded immediately in the movements of the pencil to get down the message.

R. M. YERKES.—It was suggested to us early in this work that there was some special reason for the high rank of the engineers. We analyzed our results to find out whether the tests were easier for men with mathematical training. The evidence pretty thoroughly indicated that the engineers deserve the position which our tests give them.

It is interesting to know that in the army schools for chaplains, extremely high ratings appeared. We compared the chaplains' records with those of engineers and medical men and found that the groups had obtained their ratings in different ways. The chaplains were skilled in the use of languages and they scored heavily on the tests that depended largely on language, whereas the engineers were stronger on the reasoning tests.

B. F. TILLSON.—May I ask whether these tests showed whether a man were moral or honest and whether he was likely to go to sleep on the job?

R. M. YERKES.—The tests measure intelligence or mental alertness; nothing else.

Die Castings and Their Application to the War Program

Discussion of the paper of CHARLES PACK, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 239.

JESSE L. JONES,* Pittsburgh, Pa. (written discussion†).—As the die-casting process is so very different in character from the process of making sand molds, it is often considered that entirely different methods of pouring, gating, venting, etc. should be used. There is really, however, no essential difference in the making of die castings and sand castings, and similar methods should be used in each process.

In the matter of gating, the metal should be introduced at a central point, as nearly as possible, so that it will have an equal distance to flow from the point of entrance to the most distant points of the mold. This will cause a uniform rate of congealing of the casting and prevent streaks and cold shuts.

The venting should be done in such a way that a free exit of the air in the molds can occur. It should be less difficult to take care of the venting of a die-casting mold than to vent an ordinary sand mold. In the case of a sand mold, the venting is left, to a considerable extent, to the judgment of the molder, and it is possible that no two molds will be vented in a similar manner. Further than this, after a vent has been made in a sand mold, it may become clogged by the sand and for this reason be inefficient. There is also quite a variation in the pressure of the metal entering a sand mold, due to varying heights of the pouring gate. In a die-casting mold these factors can be controlled more closely. The vents should be so disposed that the air in the mold compressed by the entrance of the metal may be able to leave the mold at a uniform rate and by exits located symmetrically. These exits are made quite small on molds at first, as they can be easily enlarged if necessary, and they are tapered so that a free flow is guaranteed without danger of the metal spurting out from the die. Uniformity of pressure of the metal as it enters the mold is very important and, as the pressure is mechanically applied, its control is not difficult.

It is true that a sand mold has much less of a chilling effect on the metal poured into it than has the die-casting mold, but, outside of this point, there is a great similarity between the die-casting process and the process of making castings in sand molds. It is suggested that much would be gained by regarding these two processes as not essentially different.

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* Metallurgist, Westinghouse Electric & Manufacturing Co.

† Received Feb. 13, 1919.

Automatic Copper Plating

Discussion of the paper of J. W. Richards, presented at the New York meeting, February, 1919, and presented in *Bulletin* No. 145, January, 1919, p. 27.

A. Silverman,* Pittsburgh, Pa.—Prof. Richards has described a very interesting process. In addition to the method described, electroplating and a number of other processes have been used. In one, the two metals were heated and united under hydraulic pressure; in a second, the steel was coated with an alloy, brass for example, and the molten copper cast around this. The process that I would like to bring to the attention of the metallurgists present consists simply of pouring molten copper, brass, or cupronickel around a clean red-hot steel billet. It is covered by the Roth patents. The 8-in. cylindrical billet containing about 70 per cent. steel (core) and 30 per cent. copper is hot drawn or rolled until several inches in diameter and afterward cold drawn or rolled to rod, wire of any desired diameter, or sheet. The wire is used for electrical conduits where conductivity and high tensile strength are required, also for the manufacture of cables and screen cloth. The sheet is employed for the manufacture of spouting, molding, shells, etc.

The last application is particularly interesting. In testing rifle cartridges, which usually contain lead-filled copper noses, pine boards 1 in. thick, covered with ¼-in. rawhide, are placed 1 ft. apart. The value of the cartridge depends on the number of boards penetrated by the bullet. In government tests made with copper-coated steel noses (15 per cent. copper on either side of the steel) the penetrating power was found to be approximately double that of pure copper noses. The advantage of copper-coated steel over cupronickel lies in the fact that the former does not require any special heat treatment during the punching. Rifle cartridges were prepared from copper-coated steel in a number of government arsenals. The value of the combination was attested by the awarding of a contract for the construction of a $3,300,000 plant. Unfortunately, the contract was signed on the day preceding the signing of the armistice and was cancelled several days later. Tests were conducted for about 1 yr. before the contract was awarded to determine the value of this combination of metals. Since the war a number of cartridge and shell manufacturers have signified their intention of using copper-coated steel.

Many other interesting applications of copper, brass, and cupronickel-coated steel are possible. Copper-coated steel springs have already been manufactured. Ground pins and connecting wires for rails are in use.

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Wire 0.005 in. in diameter looks like pure copper or brass depending on the coat, and thin sheet also resembles the pure metal. In fact, were it not for the springiness of the steel filling, one could not tell the coated material from the pure copper or brass. Copper- and brass-coated steel, as their value becomes apparent, will take an important place in the metal industry of the near future.

First Year of Leaching by the New Cornelia Copper Co.

Discussion of the paper of H. A. TOBELMANN and J. A. POTTER, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 449.

C. A. ROSE, New York, N. Y. (written discussion*).—Without doubt the excellent results obtained at Ajo will cause surprise among metallurgists; 75 per cent. average capacity and 80 per cent. extraction during the first year of operation of a plant using a new metallurgical process are figures that speak for themselves.

It is obvious that the most troublesome feature of the process is the fouling of solutions. The effects of this are most evident in the electrolytic tank house; but apparently the solutions are so heavily loaded with salts that their dissolving power is also impaired. This is indicated by the fact that copper comes into solution during washing after the leaching of the ore is completed, as shown by the decreasing ratio of acid to copper in the various washes tabulated in Table 4, and also by the fact that 4.9 per cent. of the total copper in the ore remains in the tailings in a soluble form.

Even though the extraction in leaching and the ampere efficiency in electrolysis would be benefited by keeping the salts in solution at a lower concentration, it is doubtful whether it would pay to decrease these salts by discarding more electrolyte without other changes in the process, since this would increase the amount of cement copper produced, which is already very large. If, however, it would not disturb the process otherwise, this object could be accomplished by increasing the range of electrolysis, so that solution going to the tank house would contain, say, 4 per cent. copper and 1 per cent. acid, and the solution returned to the leaching plant 1½ per cent. copper and 4.8 per cent. acid, and by increasing the volume of solution to be discarded, this to be taken from the electrolyzed solution returned to the leaching plant. By this arrangement, more salts will be removed from the system per ton of cement copper produced; and if sufficient solution is discarded to keep the iron content down to 1½ per cent. it would be feasible to recover the copper from

*Received Feb. 14, 1919.

this wasted solution by electrolysis. In order to keep the iron down to 1½ per cent., it would be necessary to discard a volume of solution about twice as great as at present. This would mean an additional loss of 25 to 30 tons of acid per day in the wasted solution, but it is very probable that the increased extraction in the leaching plant and the better ampere efficiency in the tank house would more than compensate for this loss of acid.

The average ampere efficiency in the tank house, calculated from the average voltage and pounds of copper deposited per kw. hr. given in the tabulation, was about 63 per cent. If the iron in the electrolyte is kept below 1½ per cent., there is no doubt that the ampere efficiency in the commercial tanks can be increased to more than 80 per cent. and that the copper recovered from wasted solution will be deposited out to as low as ½ gm. per liter, with an average current efficiency of at least 50 per cent. It would also seem advisable to use a higher current density, since this would increase the ratio between the copper deposited to the copper dissolved from the cathodes by the ferric sulfate in the electrolyte.

Apparently 65 per cent. of the oxygen liberated at the anode is taken up by the ferrous sulfate in the electrolyte and yet the drop of potential between the anode and cathode is 2 volts. It would seem, therefore, that very little benefit as a depolarizer is derived from the reduction of the solution by SO_2.

The advantage of the great amount of circulation in the leaching tanks is not apparent unless it be aeration of solutions. Also, it is doubtful whether the ferric iron in the solutions has any beneficial effect in the leaching operations, since the solution delivered by the leaching plant contains more ferric iron than that received from the tank house. Perhaps the continued dissolving of copper during washing operations is due to the aeration which results when the ore is drained between washings. If this is the case, it might pay to drain the ore several times during the leaching period. A saving of about 8 per cent. of the power generated could probably be made by substituting rotary converters for motor-generator sets.

Stuart Croasdale,* Denver, Colo. (written discussion†).—It is very gratifying, on reading the paper of Messrs. Tobelmann and Potter giving the results of the first years' operation of the New Cornelia Copper Co., to learn how closely these results check with those obtained at the pioneer experimental plant for this ore at Douglas, Ariz., where these gentlemen so ably and so faithfully assisted me in blazing the way for the plant now in operation at Ajo. A few comparisons are interesting: 192.4 tons of ore was treated at the Douglas plant, having an average

* Consulting Engineer. † Received Feb. 19, 1919.

content of 1.43 per cent. copper; the copper left in the tailings was 0.32 per cent. At Ajo 1,345,000 tons of ore was treated during the first year, having an average content of 1.63 per cent. copper; the copper left in the tailings was 0.338 per cent.

Perhaps the most important part of the paper is that dealing with the consumption of acid and the fouling of the solutions. In my preliminary laboratory experiments at Douglas, I varied the strength of the acid lixiviant from the amount theoretically necessary to dissolve the copper in the ore, up to a 10 per cent. solution. The theoretical amount necessary to dissolve the copper in this case happened to be a 3 per cent. solution of 100 per cent. H_2SO_4. This acid solution, or lixiviant, corresponds to the acid advance mentioned by Tobelmann and Potter. Before precipitating the copper, the excess of acid was neutralized by circulating the lixivium through new ore, as is done at Ajo.

In some of the tests made in the experimental plant at Douglas, the acid in the lixiviant was reduced as low as 1.7 per cent. but, in order to acquire information as quickly as possible, most of the tests were made with a 10 per cent. acid solution and the leaching extended over a period of three days, exclusive of washing. My tests with a 10 per cent. acid solution gave an average consumption of 3.15 lb. of 100 per cent. H_2SO_4 per pound of copper dissolved. My laboratory tests with a 5 per cent. acid solution gave an average consumption of 2.5 lb. of acid per pound of copper dissolved; while in the experimental plant, the same strength of solution gave a result of only 2.0 lb. of acid consumed after a period of five to six days leaching, exclusive of washing. In tests made at the 40-ton experimental plant at Ajo, the consumption of acid was 2.8 lb. per lb. of copper dissolved when a 3 per cent. lixiviant was used, and the leaching extended over a period of eight days.

The first year's operation of the large plant shows an average consumption of 2.76 lb. of acid per pound of copper dissolved when using a 3 per cent. acid lixiviant and extending the leaching period to eight days. During the last four months of the year, however, the acid consumption was reduced to 2.14 lb. and the leaching period to six or seven days. Apparently the 3 per cent. acid advance has yielded no less acid consumption than the 5 per cent. solution that I used, while the time of leaching has been necessarily extended as a consequence of the weaker lixiviant.

On comparing the analyses of the lixiviums that I obtained, using both strong and weak acid solutions, with those obtained during the first year's operation at Ajo, the question arises whether the anticipated advantage has been gained in the direction of cleaner lixiviums by using the lowest strength acid lixiviant.

Probably all of the soluble iron in this ore is derived from the oxidised pyrite and chalcopyrite. Owing to the climatic conditions of the Ajo

district, the oxidation of these minerals has left both the physical and chemical conditions of the iron in such form as to be quite readily dissolved in an acid solution of any strength. The iron seems to follow the copper rather slowly in relative solubility, but it passes into solution with increasing rapidity as the time of leaching is lengthened, even with a weak acid solution.

The soluble alumina is probably derived from the decomposed feldspars that have been kaolinized by ordinary weathering of the rock assisted by the acid from the oxidation of the pyrite. The alumina follows the iron closely in relative solubility. It also passes into solution with increasing rapidity as the time of leaching is lengthened, to a greater degree than the iron.

Of course no leaching is accomplished if the lixiviant is not sufficiently acid to overcome the basicity of the ore and a positive disadvantage results. Copper is necessarily precipitated in the ore, which has to be redissolved by the more acid lixiviants that follow. Basic sulfates of iron and aluminum are almost sure to form, which will have a tendency to separate out as a slimy flocculent precipitate in the neutral or weakly acid lixiviums.

It would be interesting to learn if the so-called slimes that have given trouble in the SO_2 towers, electrolytic tanks, and scrap-iron launders, are not largely basic sulfates of iron and aluminum rather than colloidal slimes from the ore. If this can be determined, it might be suggestive in the future treatment of the ore. With upward percolation, however, I presume the tendency for the colloidal slimes to follow the solutions is greater than it would be with downward percolation.

I have gone into this subject somewhat at length in order to support my belief and original recommendation in favor of a stronger acid advance and a shorter period of leaching. I do not recommend using the 10 per cent. acid lixiviant that I used at Douglas, because that was unnecessarily high for the reasons already stated; but with a knowledge of the results now at hand, I do believe a 5 per cent. solution can be used advantageously over the 3 per cent. solution now in use without increasing the consumption of acid per pound of copper dissolved.

The next interesting feature of the year's work is the resumed effort to utilize the iron in the calcines, in the form of sponge iron, as a precipitant for copper. As the authors have stated, my investigations along this line at Douglas were brought to a close about the time we had learned nearly everything we should not do and before we had been able to devise a furnace of commercial value that would effect a complete reduction of the calcines at a comparatively low temperature. This work was taken up later by the Anaconda Copper Co. and sponge iron was made in quantity at Anaconda by heating calcines and coal in a Bruckner furnace by means of an oil burner. In discussing this sub-

ject with Mr. Laist a few years ago, he said they found that the reduction of the iron oxide to FeO was accomplished quickly at low temperature; but to complete the reduction to metallic iron required an unexpectedly high temperature, which added considerably to the expense, and since they always had sufficient scrap iron on hand to meet their precipitation requirements they abandoned the reduction of calcines.

My own investigation, when using this method of reduction, had already confirmed the Anaconda results and had led me to seek lines of less resistance that would yield metallic iron at lower temperatures, which I had good reasons to believe could be obtained. That iron oxide, particularly as it occurs in calcines, can be completely reduced to metallic iron at temperatures under 1600° F., or 900° C., has been demonstrated by myself as well as other investigators. In common parlance, this is a cherry-red heat. There is no difficulty about the chemical part of the process. The problem lies in constructing a commercial furnace that will enable one to bring about the chemical reactions when operating continuously on a large scale. The conditions of the problem are not insolvable.

F. S. SCHIMERKA,* Clifton, Ariz. (written discussion†).—Messrs. Tobelmann and Potter have made a very notable contribution to the hydrometallurgy of copper by revealing with painstaking thoroughness the inner workings of the Ajo plant, the development of which has been followed with great interest by all whose attention is directed toward the wet treatment of oxidized copper ores. We have been treated to a metallurgical feast and, as regards the abundance of data furnished, with a generosity deserving of high appreciation.

It cannot be denied that the animosity against the treatment of copper ores by wet methods has only lately been overcome. Metallurgists have been less outspoken in this animosity than was capital, which hesitated to engage in a large-scale project along new and substantially untried lines. The practicability of the process required demonstration by leaders and it has been furnished by the success that has attended large enterprise. The frank statement of the authors that neither metallurgically nor mechanically is there anything radically new in the process detracts nothing from their achievement, which consists in the surmounting of very considerable difficulties in the way of practical application of known principles.

The two distinct phases of the process are the lixiviation of the copper and the deposition of the metal. Of these the last is, in the larger number of cases, the crux of the process. The reclamation of the metal from its liquors has tried the skill of the metallurgist to no trifling degree. Setting aside the method of precipitation by scrap iron, the brutality of which,

* Arizona Copper Co., Ltd. † Received Feb. 20, 1919.

borrowing the expression from a leader, has not interfered with its popularity and application as a last resort, the task of the final separation of the metal with completeness and commercial purity is an operation requiring skill and circumspection. How far this task has been solved at the New Cornelia is shown with commendatory minuteness in the paper under discussion. It is difficult to hold the composition of a commercial electrolyte within the limitations imposed by the requirements for high efficiency in the metal deposition and great care must be taken in its preparation.

It is gratifying to hear of the efficiency of sulfur dioxide as a reducer of ferric iron and of the negligible corrosion of hard-lead anodes, because predictions as to the impracticability of both have been frequently made. The regeneration of acid in the reduction process forms a valuable asset and, as regards the question of a serviceable insoluble anode for the electrolysis of sulfate liquors, we recognize that the subject has caused more agitation than was warranted.

It must be regretted that electrolysis will not practically lend itself to a more complete exhaustion of the copper in the discard liquors. We hear that it is doubtful economy to continue electro-deposition in solutions containing as much as 1.71 per cent. copper, by which time the ampere efficiency has dropped below 50 per cent.; and that precipitation by scrap iron is resorted to before this point is reached with the result that a good part of the output appears as cement copper.

The problem of profitable copper deposition, by electrolysis, of low-grade solutions is one of absorbing interest in the Southwest, where leaching plants will soon become a necessary addition to concentrators working up mixed ores. The radical difference between such a supplementary plant and the conditions existing at Ajo is the great dilution of the liquors, which cannot be separated from the leached pulp by draining and stage washing but only by dilution and decantation on account of the slimy nature of the product to be leached. A high concentration of copper in liquors from a material in which about 60 per cent. of the sizes are minus 200 mesh and frequently carry less than 0.5 per cent. copper is indeed impossible, if the separation of the liquor must be effected by settling and decantation; and the practice of leaching such a product by counter-current has as its object rather the economical use of the acid than a concentration of the liquior, except as far as an increased extraction raises the copper contents in the solution. In connection with this subject, it would be of interest to learn whether any progress has been made in the designing and application of real practical diaphragms. These have been proposed as a means for reducing the power consumption in the electrolysis of low-grade solutions. Any data bearing on this subject would be highly welcome. As far as I am aware, the difficulty is encountered in the creation of a durable diaphragm for solutions whose

acidity increases with their depletion. If, without a diaphragm, the power consumption increases to 3 kw. hr. per pound of metal deposited from solutions containing 0.5 per cent. of copper, there is but little hope that electrolysis will play a great role in the working up of liquors from leaching plants that are operated in continuity with the milling process. The treatment for recovery of the acid-soluble copper in weathered tailings does not come within the frame of my present consideration; they can be reclaimed in a comparatively dry state and treated with the advantages that result from this condition. Neither do I refer to any so highly oxidized material as would today constitute primarily a bad milling ore.

The high price of scrap iron in many localities, the expense of handling it, the high consumption in the precipitation from poor solutions, the large launder or tank equipment, and the production of a low-grade cement have each contributed in no small measure to bringing this method into disrepute. Therefore the positive statement of the authors predicting the early possibility of producing sponge iron successfully and at a price at which it can enter into favorable competition with scrap, will be welcomed by those who are in a position to take advantage of it and have themselves experienced the trials of an antiquated method.

J. W. Richards,* South Bethlehem, Pa.—It should be very comforting to those who are working with insoluble anodes that the antimonial lead anodes, during a period of a year, had practically failed to show any marked deterioration, so that, so far as they are concerned, the very important problem of the unattackable anode seems to be solved. Another point worth attention is the use of the little conical, glazed, porcelain insulators to keep the anodes spaced properly away from the cathodes, a very simple device that apparently does its work satisfactorily.

Electric Furnace Problems

Discussion of the paper of J. L. McK. Yardley, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 142, October, 1918, p. 1593.

Jesse L. Jones,† Pittsburgh, Pa. (written discussion‡).—From a commercial standpoint, the most important characteristic of the electric furnace is the ease with which it lends itself to intensive production. The melting of non-ferrous metals, as usually done in crucible, open-flame, reverberatory, and similar furnaces, has certain disadvantages which are absent in the electric furnace, viz.:

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† Westinghouse Electric & Manufacturing Co. ‡ Received Jan. 17, 1919.

1. There is contact of the material being melted, for a long period, with air, which results in the formation of oxides and dross and, in the case of some metals, nitrides. If clean castings are desired from such metal, skim gates, risers, and similar devices must be used. The large amount of extra metal required greatly increases costs while the dross, if once formed, can never be perfectly removed, so that absolutely clean castings cannot be obtained. Moreover, any dross included in a casting, being of an abrasive nature, adds to the expense of the machining.

2. A prolonged period of melting will cause absorption of hydrogen, carbon monoxide, and other gases from the products of combustion of the fuel. The release of these gases during solidification results in spongy castings.

3. Contact of molten metals for long periods with the refractory materials of crucibles, furnace linings, etc. results in silicon, silicates, iron, iron oxides, alumina, etc. being alloyed, or entangled, with the molten metal and resulting marked disadvantages.

4. Slow melting largely increases volatilization losses in the case of many metals. It requires more floor space for molds, causes loss of time by employees if the molds are ready in advance of the metal, and, where crucibles are used, diminishes the life of the crucible.

Possibly greater speed of melting has been obtained in the oil-fired open-flame furnace, up to the present, than in any other type of furnace. A record has been made of 26 heats of 500 lb. each of brass in a working day, in a furnace of this type. Individual heats of 500 lb. have been made in 15 min. actual melting time, and heats of 300 lb. in 8 min. This rapid work has been made possible by the liberal use of fuel and the stored heat in the furnace linings.

Mr. Yardley has shown that a very large input of current may be made to the electric furnace and it is the object of this discussion to emphasize the economic advantages that may result from the satisfactory application of such heavy currents. Possibly we may never be able to melt metals in the electric furnace instantaneously, in a reducing atmosphere and with a minimum of volatilization loss, but the electric furnace has more possibilities of approximating these ideal melting conditions than any melting device of which we have any present knowledge.

Comparison of Grain-size Measurements and Brinell Hardness of Cartridge Brass

Discussion of the paper of W. H. Bassett and C. H. Davis, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 145, January, 1919, p. 57.

T. C. Merriman, New Haven, Conn. (written discussion*).—This most interesting paper gives much carefully obtained and valuable data. However, there are two points in connection with the commercial application of such data that might possibly be a source of trouble and misunderstanding. In the first place, the examination of thin sections of annealed brass, subjected to standard Brinell test (500 kg. on a 10-mm. diameter ball) at thicknesses from 0.075 to 0.150 in. (1.9 to 3.8 mm.) indicates that cold work has been performed on the specimen during the application of the load sufficient to extend way through the section and have the hardness of the metal affected by the backing. If the usual steel support is used, this effect is very evident. If a piece of soft brass is used as a support, there is an indentation in the surface of the support accompanied by a bulge on the under side of the tested specimen opposite the impression made by the 10-mm. ball. The result is that Brinell specifications (governmental or otherwise) on stock for a certain purpose may not be fair in all cases, since manufacturers, owing to differences in equipment, etc., may not all use precisely the thickness and conditions of stock on which the Brinell specifications were based. This would mean that the government Brinell specification might not give them the temper of stock best suited for their manufacturing methods.

The concluding paragraph of this paper, stating that "the hardness of cartridge brass may be determined with greater accuracy by the Brinell hardness measurement than by attempting to judge it from the grain size" appears to be in line with the movement of the last year or so among brass manufacturers toward substitution of the Brinell test for microscopic examination as an acceptance test on cartridge brass. The statement may be strictly true that the Brinell test is the best test for hardness, but it is not, as the statement might readily be construed, a sufficient test of suitable condition. For instance, some cartridge brass might accidentally have been overheated to a point where it would be distinctly unsafe to use for the manufacture of small arms cases and then be so rolled (reduction 3 to 5 per cent.) as to pass perfectly proper Brinell specifications. Under such conditions the microscope would reveal its unsuitability where the Brinell test had failed so to do.

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* Received Feb. 24, 1919.

It is not intended to object to the Brinell test as a general test for the temper of cartridge brass, for I am in full agreement with the authors as to the usefulness and suitability of the Brinell test under many conditions, and I am sanguine that the development of the "Baby Brinell" will eliminate the likelihood of difficulty from the first point I have mentioned. However, Brinell specifications for cartridge brass are as yet given for 500-kg. load—10-mm. ball, and I firmly believe that even after the baby Brinell comes into fairly general use the Brinell test must be supplemented by frequent microscopic examinations and that microscopic inspection requirements should be retained as a vital part of cartridge-brass specifications.

C. H. MATHEWSON, New Haven, Conn. (written discussion*).—Recent papers from Mr. Bassett's laboratory constitute a very welcome addition to the rather meager amount of scientific literature dealing with structure and properties, or in other words, the metallography of brass. They seem to have been developed mainly from the standpoint of supplying reliable and useful data that may be expected to further the intelligent handling of brass products. The collected data shown in the tables, when exhibited in graphic form, present several features of general interest and significance. There is a striking difference in the early parts of the several annealing curves shown in Fig. 1. While the heavily worked samples harden quite materially before they begin to soften, the lightly worked samples soften without any prior hardening.

The fact that hardening sometimes occurs after treatment at low temperatures before a true annealing effect begins has been known for some time, but, so far as I am aware, the supplementary information brought out by these curves is quite new. This early hardening has been attributed to a redistribution or relief of internal strain, but Howe considers this explanation hardly competent to account for similar effects of much greater intensity which occur in steel.[1] Jeffries, however, in his discussion of the amorphous theory anticipates a condition of internal stress incident to the formation of amorphous metal, which may be gradually relieved at ordinary temperature or more rapidly relieved at somewhat elevated temperatures. This explanation is quite in harmony with the observation that the more severe the initial deformation, the more pronounced the hardening in question.

We might even find a relation between season-cracking, an effect of internal strain, and this unique hardening. Thus, it is conceivable that metal which has not been worked severely enough to show an appreciable hardening when heated to about 200° C. will be stable under all conditions, while metal that hardens under this treatment will be subject to season cracking. This point appears to be worth some investigation.

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* Received Feb. 17, 1919.

[1] *Bulletin* No. 146 (Feb., 1919).

It is noticeable that each curve of Fig. 1 intersects the curve lying below it in two localities before they merge into one common curve. The first intersection is due to a progressive lowering of the recrystallization temperature as the degree of deformation decreases and a reasonable explanation of these conditions has been given in the first paper cited by the authors. The second intersection indicates that when the more severely worked metal has nearly completed its recrystallization, and the less severely worked metal has recrystallized to a considerably lesser extent, both possess the same hardness. This would naturally occur at some characteristic temperature and the measured grain sizes would not be the same because there would be a greater number of grain areas composed of invisible fragments in the case of the less severely deformed material. These measurements would be greatly influenced by the grain size that existed prior to deformation and the authors have alluded to the bearing of this factor on the results.

It is quite probable that the less severely deformed material may develop abnormal grains, at favorable temperatures, by selective growth and this may account for the widening of the loops made by the last intersections of the curves of Fig. 1 as the degree of deformation decreases.

In the discussion of Dr. Jeffries' paper, I have referred to the relationship between Brinell hardness and grain size indicated by Fig. 3. of the paper by Messrs. Bassett and Davis. Using the equation:

$$\text{Brinell hardness} = K \frac{1}{\sqrt[4]{\text{diam. of average grain in mm.}}}$$

and placing the constant equal to 30 the following set of figures is obtained. These plot rather close to the curve shown in Fig. 3.

Brinell Hardness	Diameter of Average Grain, in Mm.
43	0.2401
50	0.1296
60	0.0625
75	0.0256
100	0.0081
150	0.0016

It is interesting to observe that beyond a hardness value of approximately 75, at which point grain-size measurements became impracticable, the authors carry dotted extensions of the curves up to the limiting hardness value of the cold-rolled metal, 160. In other words, they represent a continued decrease in grain size down to a minimum of zero size at the maximum hardness value.

Any attempt to count in this range would show a reversal of grain size with hardness and the grain size corresponding to maximum hardness

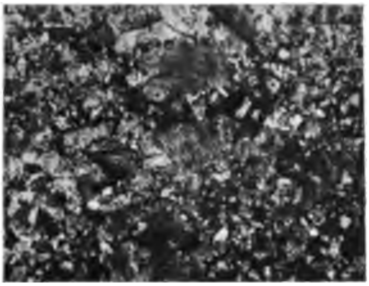

FIG. 1.

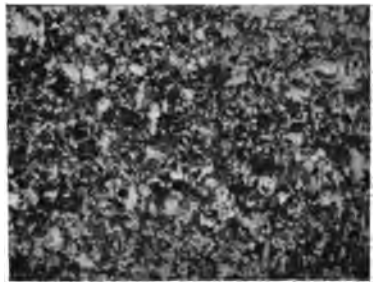

FIG. 2.

FIG. 1.—SHEET BRASS ROLLED 4 NUMBERS AND ANNEALED ½ HR. 350° C.
FIG. 2.—SHEET BRASS ROLLED 7 NUMBERS AND ANNEALED ½ HR. 350° C.

FIG. 3.

FIG. 4.

FIG. 3.—HIGH SIDE OF ECCENTRIC SHELL WHICH FAILED IN MERCURY TEST. 1 MIN. 800° F. (427° C.)
FIG. 4.—LOW SIDE OF ECCENTRIC SHELL WHICH FAILED IN MERCURY TEST. 1 MIN. 800° F. (427° C.)

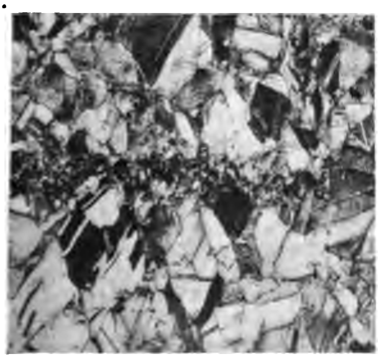

FIG. 5.

FIG. 6.

FIG. 5.—HIGH SIDE OF SCRATCHED ECCENTRIC SHELL. 1 MIN. 800° F. (427° C.)
FIG. 6.—LOW SIDE OF SCRATCHED ECCENTRIC SHELL. 1 MIN. 800° F. (427° C.)
$NH_4OH + H_2O_2$ × 75.

FIG. 7.

FIG. 8.

FIG. 7.—HIGH SIDE OF SCRATCHED ECCENTRIC SHELL. 1 MIN. 850° F. (454° C.)
FIG. 8.—LOW SIDE OF SCRATCHED ECCENTRIC SHELL. 1 MIN. 850° F. (454° C.)

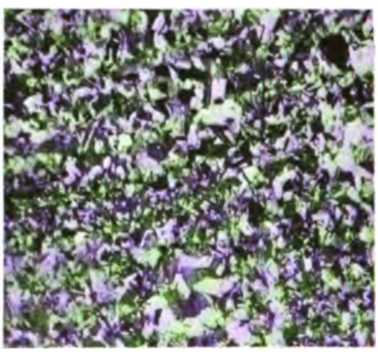

FIG. 9.

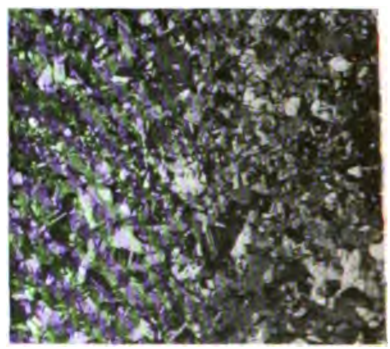

FIG. 10.

FIG. 9.—HIGH SIDE OF SCRATCHED ECCENTRIC SHELL. 1 MIN. 900° F. (482° C.)
FIG. 10.—LOW SIDE OF SCRATCHED ECCENTRIC SHELL. 1 MIN. 900° F. (482° C.)

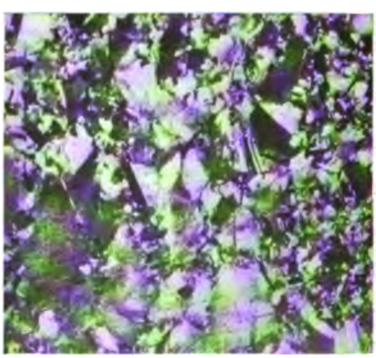

FIG. 11.

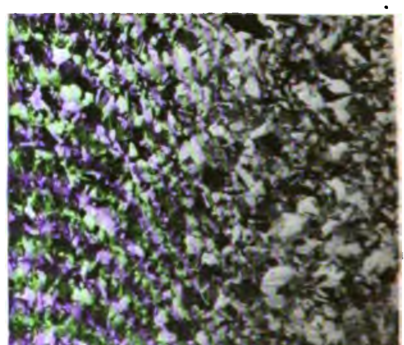

FIG. 12.

FIG. 11.—HALF SHELL 1 MIN. 800° F. (427° C.)
FIG. 12.—HALF SHELL 1 MIN. 900° F. (482° C.)
$NH_4OH + H_2O_2$ × 75.

would be the cold-worked equivalent of the original grain. The theoretical curve passes through decreasing values of grain size in this region down to a minimum of about 0.001 mm. at the maximum hardness value of about 160. This represents what I conceive to be the order of size of the indistinguishable crystalline grain fragments present in severely worked brass and I look upon the process of hardening by cold working as essentially a process of fragmentation with a building up of amorphous or subcrystalline boundaries.

W. B. Price,* Waterbury, Conn. (written discussion†).—The practical application of Brinell hardness measurements in controlling the annealing of cartridge brass is of very great importance. While it is realized that the paper under discussion is supposed to deal only with the relation between grain size and Brinell hardness, it would have been interesting if other physical properties could have been added. In connection with the anneal shown at 350° C. with different reductions, analogous annealing experiments were carried out in this laboratory in 1914, with common high brass (copper, 64.13 per cent.; lead, 0.21 per cent.; iron, 0.04 per cent.; zinc, 35.62 per cent.) reduced four and seven numbers hard (Brown & Sharpe gage). These results are illustrated by Figs. 1 and 2.

It may be of interest to state in connection with the author's conclusions, "the grain size of brasses annealed at low temperatures are greatly affected by the grain size and the reduction by rolling previous to such annealing," an experience with low-temperature anneals on the *mouth* annealing of brass artillery cases. Occasionally a little trouble was experienced with a shell cracking on the mouth in the mercuric chloride *test*, and upon investigation it was found that failure usually took place upon the thin side of an eccentric shell. The photomicrographs of a shell that failed are shown in Figs. 3 and 4. The mouth anneal of 1 min. at 800° F. (427° C.) has caused a partial recrystallization on the thick, or more heavily worked, section, while there is very little evidence of recrystallization on the thin, or little worked, section. By raising the temperature of the anneal high enough, recrystallization was effected regardless of variation in amount of reduction on the mouth.

Another practical illustration of the important relationship between degree of cold working and temperature of recrystallization was noticed in a case that had been rather deeply scratched by an imperfect die previous to the mouth anneal. Examination under the microscope, after the annealing treatment, showed that recrystallization had taken place on the scratch but had not appeared on other parts of the case. Some cases were then purposely scratched and annealed for 1 min. at 800°, 850° and 900° F. (427°, 454° and 482° C.) (see Figs. 5 to 10). Recrystallization of the specimen was hardly effected at 850° F. (454° C.); incipient

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* Scovill Mfg. Co. † Received Feb. 17, 1919.

recrystallization has taken place both on the scratch and on some of the boundaries of the large deformed crystals. At 900° F. (482° C.), recrystallization has replaced the large originally deformed crystals with a much finer structure. The crystals on the scratch are much smaller than those on the unaltered section.

The relation of crystal size to tensile strength and per cent. of elongation is illustrated by the following experiment: A concentric shell was cut in two longitudinally; one half was annealed for 1 min. at 800° F. (427° C.) and the other half was annealed for 1 min. at 900° F. (482° C.). These are illustrated in Figs. 11 and 12. The 800° F. (427° C.) case when tested had a tensile strength of 57,385 lb. per sq. in. (4034 kg. per sq. cm.) and an elongation in 2 in. of 35.3 per cent., whereas the 900° F. (482° C.) case had a tensile strength of 51,567 lb. (3620 kg.) and an elongation of 52.2 per cent.

On pages 63 and 77, the authors state that in annealing hard rolled metal the drop in Brinell hardness indicates softening of the metal just before the new grains are seen. Upon examination of Fig. 1, page 62, however, showing graphically the relation between the Brinell hardness values and the annealing temperatures, it will be noted that the hardness curve rises perceptibly from the hard material to the 200° C. anneal for metal reduced 36.6 per cent. and upward. This indicates that for temperatures below visible recrystallization, possibly amorphous, material resulting from severe working undergoes some readjustment, which causes a distinct hardening instead of softening as would generally be expected. This phenomenon was observed by Mathewson and Phillips,[2] and came under my observation[3] when I annealed artillery cases at low temperatures.

J. BURNS READ,* Washington, D. C.—There is nothing I can say other than in support of the data that Messrs. Bassett and Davis have furnished. In fairness to them, after what Mr. Phillips has said,[4] I wish to state that these data were in the hands of officers of the Ordnance Department early last year and were very helpful in the manufacturing of cartridge cases for both small arms and artillery. Many contractors who undertook the manufacture of cartridge cases knew nothing of the control of brass quality through its working and anneal, consequently this information was most helpful and such troubles as too soft and too hard cases and season or corrosion cracking of cases were readily overcome through the application of the principles brought out in this article. A large number of micrographs and records of Brinell tests collected by the Ordnance Department certify as to the correctness of the data.

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[2] *Trans.* (1916) **54**, 608–657.

[3] W. B. Price: A. S. T. M. (1918) **18**.

* Captain, Technical Staff, Ordnance Dept., U. S. A.

[4] *Bull.* 147 (March, 1919).

The question of Brinell tests has been given much attention by the Ordnance Department. As stated, the Brinell test has not been reliable when applied to thin material, and if it makes an impression through to the other side of the metal it is no longer a Brinell test.

The Ordnance Department in its laboratory at Pittsburgh has been working on the development of what it calls a baby Brinell machine, and has obtained some very satisfactory results in the brinelling of thin sheet metals. Since the signing of the armistice, this machine has been used in the direct brinelling of 0.30 caliber cartridge cases and very consistent results have been obtained. Because of these results, we feel that the brinelling of thin sheet metal is soon to be a reliable method of determining its hardness.

W. H. Bassett.—The discussion of this paper has been gratifying and I am glad to hear the various conclusions that have been drawn from the data supplied. It was our intention to arrive at a practical method which would allow the rapid testing of cartridge brass in inspection. Of course, this work has a commercial bearing now that we are no longer manufacturing munition supplies. The Brinell standard test using the 10-mm. ball is not serviceable for thin metal, and I am glad to hear of the development of the baby Brinell; this should certainly offer a means for the more rapid testing of the hardness of thin brass.

Notwithstanding what Mr. Merriman said about the possibility of brass passing a Brinell hardness specification, in the case of over-annealing followed by light rolling, I do not believe that this fact detracts from the practicability of the Brinell test. It is, of course, possible by combinations of working to obtain false impressions from the grain count, as we attempted to bring out in the paper. If, for instance, work done on the brass is not sufficient to make apparent a deformation of the grain, the grain size will not be an accurate measure of the hardness of the material. In other words, the material may be much harder than the grain diameter indicates. Likewise, certain combinations may be arranged that will make the Brinell hardness figures misleading.

The purpose of proposing the Brinell hardness test to replace the grain count is to make possible more rapid inspection, but the two methods should be used in connection with each other. If the Brinell hardness test is used in inspection, an occasional microscopic examination should be made in order to obtain a proper understanding of the material being considered. So far as material above 0.100 in. thick is concerned, the Brinell hardness test can be trusted, provided an occasional microscopic examination is made.

Manganese Bronze

Discussion of the paper of P. E. McKINNEY, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 421.

JESSE L. JONES,* Pittsburgh, Pa. (written discussion†).—The most important criterion on which judgment of the quality of manganese bronze can be based is its freedom from lead. Not over 0.03 per cent. of lead should be present in a good grade of manganese bronze. While it is not questioned that manganese bronze with a high tensile strength and considerable ductility can be made from materials that will give a lead content of possibly 2 to 3 per cent., there is no doubt that such material, while it may machine readily, will be found to withstand the impact test very poorly, and hence be unsuited for high-grade engineering work. When lead is present in considerable amounts, it forms in small pools in the alloy and the material has little strength at these points; in fact, such spots in the metal are equivalent to nicks in a test bar as far as their effect on tensile strength is concerned. A further objection to a high lead content is the ease with which it oxidizes and its consequent tendency to produce dross.

A second characteristic of a high-grade manganese bronze is a low content of manganese. This should not exceed 0.05 per cent.; in fact, very many of the best grades of manganese bronze show, on analysis, only a trace of manganese or no manganese whatever. Manganese is a deoxidizer and its ready oxidation protects the other metals of the alloy; but if it is present in large amounts it will produce considerable manganese dioxide, which does not separate readily from the molten alloy and may produce black specks or drossy spots and render the obtaining of clean castings difficult.

Aluminum should be present in a good grade of manganese bronze in only very small amounts. A content of 0.10 per cent. aluminum is ample. Larger amounts have a tendency to increase the shrinkage of the alloy, to give the ingots and castings a white, scruffy appearance, and to prevent the beautiful, golden, oxidization color characteristic of high-grade manganese bronze and a most excellent indication of quality.

The work that the author of the paper has done is valuable from a conservation standpoint, and it will supplement, in a marked degree, the advances that have been made by a number of manufacturers of manganese bronze in utilizing the turnings from this material. A number of firms have succeeded in making a very good grade of ingot metal from turnings and other light scrap, obtaining a tensile strength and elongation

* Metallurgist, Westinghouse Elec. & Mfg. Co. † Received Feb. 13, 1919.

which, although not equal to that obtained from new metal, is still very creditable.

The lack of uniformity in manganese bronze made from the materials specified by the author of the paper, the tendency to drossy metal from the extremely high content of lead, manganese, and aluminum, which are shown by the analyses given, combine to render the commercial use of manganese bronze made from such inferior materials of doubtful utility.

There is a field, however, for what might be designated as a second-class quality of manganese bronze in the making of rather light castings. These castings can be gated in such a way that dross and oxide will be strained from the metal and clean castings thus produced. The castings set quickly; hence if the metal has a rather high shrinkage it is not so likely to be objectionable as in a heavier casting. In light castings, also, the oxidation of the metal in the mold cannot occur to any marked extent, as in the case of large molds that are very slowly filled and in which the metal is a long time congealing. Hence, the grade of manganese bronze described by the author can be used for such castings but its use in large and important castings is likely to be far from satisfactory, for the reasons named.

W. M. Corse,* Mansfield, Ohio (written discussion†).—Mr. McKinney has called attention to a very practical method of making manganaese bronze and has checked the method by about 3 years of operation. The Naval Gun Factory has an unusual opportunity to check physical results from metal in castings because every heat is tested physically and a splendid series of results is thereby on record. Very few commercial foundries, unless on government work, test every heat of metal physically. As a result, the physical properties published by commercial foundries are not backed by nearly as many tests. I mention this to bring out the fact that Mr. McKinney is not describing an occasional heat of manganese bronze but is telling of results that are checked constantly by physical tests.

The point made that the method of making manganese bronze as described is not applicable to strictly crucible practice is important; also that the method is not practicable with small quantities of metal. The fact that less than 0.75 per cent. lead is not markedly harmful to the physical properties of this alloy is interesting, particularly in view of existing specifications.

Harold J. Roast,‡ Montreal, Que.—About 2 years ago Mr. McKinney told me about mixing zinc dross with foundry skimmings, which sounded like a very difficult proposition to me. However, I tried out essentially what he has described and found it quite possible to make satisfactory

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* Manufacturing Engineer, Ohio Brass Co. † Received Feb. 17, 1919.

‡ Manager, Testing Dept., James Robertson Co., Ltd.

an occasional heat of manganese bronze but is telling of results that manganese bronze, judging the results by tensile tests, etc. The furnace used was an oil-fired revolving furnace of 1000 lb. capacity. Unfortunately, the company for which I was working did not require the bronze at that time; but my experience, small as it was, leads me firmly to believe that what Mr. McKinney has said is feasible, and I would strongly advise anyone interested to try it out.

G. H. Clamer,* Philadelphia, Pa.—I have been more or less familiar with the work Mr. McKinney has been doing in the Washington Navy Yard, but I did not appreciate that he was carrying the consumption of scrap quite to the extent he has described.

The original manganese bronze, known as the Parsons manganese bronze, was introduced into America 25 or 30 years ago by the Wm. Cramp Ship and Engine Building Co. It was always considered an alloy of the highest order; that is, it required knowledge, experience, and the use of raw materials of the highest quality to produce it, in order to get satisfactory results. Lake copper was used and the Bertha, or Horsehead spelter. I think possibly that I was the first one to make manganese bronze in this country, independent of the Cramp Co. There was practically no information on the subject at the time I started; there was nothing in the literature, except that we knew that Parsons manganese bronze was a very good metal and was very largely used by the United States Government. The Cowles Co., of Lockport, then introduced aluminum bronze, which carried about 10 per cent. of aluminum and 90 per cent. copper; there was a great deal of discussion and controversy, as to the relative merits of these two alloys. Finally the manganese bronze won out, because it was more easily handled and could be more cheaply produced. The Cowles Co. then undertook to manufacture manganese bronze. They manufactured the alloy by the use of manganese copper and actually introduced a considerable proportion of manganese into the alloy, and I will say that the bronzes they made at that time, carrying about 4 per cent. of manganese and as high as 1¼ per cent. of aluminum, were as good bronzes as I have seen. These alloys had a very high yield point, good elongation, and tensile strength, in some cases as high as 90,000 pounds.

After we began to manufacture manganese bronze, several others began its manufacture, so, naturally, the producer started to look for cheaper methods of production. The first step was to use a lower grade of spelter; consequently, the intermediate grades of spelter, carrying 0.2 per cent. of lead were used. After that, there was some scrap used but the scrap was always of a strictly known quality and of low lead content. We also used zinc dross in making this alloy about 10

* First Vice-president and Secretary, Ajax Metal Co.

years ago, appreciating the fact that in zinc dross we had a ready means for introducing iron into the alloy. The alloys were made merely by the use of zinc dross, aluminum, and copper and gave very satisfactory results; these alloys contained no manganese whatever. We were very careful, however, to use only the zinc dross that came from high-grade spelter, the spelter of very low lead content, such as is produced in galvanizing wire. We found that by using drosses of that kind we could get very satisfactory results, but it was hard to obtain drosses that ran sufficiently uniform to use without a great deal of care. Some of the slabs of dross we obtained evidently were mixed with dross from the use of lower grade spelter and contained 2 to 3 per cent. of lead. Other slabs contained no lead at all, so, for that reason, the use of zinc dross was given up.

We have been led to believe that the reverberatory furnace is an exceedingly bad type in which to make manganese bronze. In this furnace it is rather hard to control the atmosphere and one of the chief difficulties that I would see in making manganese bronze as Mr. McKinney describes would be in the oxidation of the aluminum. Aluminum forms an infusible oxide, unreducible by carbon at the prevailing temperatures, which is exceedingly hard to get out of the metal. It is probably fluxed by the salt that he uses and carried to the top, but I would be a little afraid of using bronze of that kind on large and important castings.

In making the test bars, as they are ordinarily made with a coupon or in the ingot, as Mr. Jones has said, it is easy to get a good test; but when you dig right into the body of the casting, I am afraid that the results obtained by that method would be somewhat uncertain. Mr. McKinney has certainly had a vast experience; he has made lots of castings and he is not putting forth here anything that he has done in a small way but I would like to ask if he has investigated the condition of the metal, in the heart of the castings, as compared with the test bars.

The U. S. Government specifications, I might say, as Mr. Corse has also pointed out, are very rigid as regards lead content and use of scrap. This paper, coming from a representative of one of our government departments, is significant. I think the Navy Department should be willing to modify their specifications, if they will accept material of that kind made by the Navy Yard.

C. R. SPARE,* Philadelphia, Pa.—The writer of the paper has informed me that about 1,000,000 lb. have been made in this way in the last year; certainly this is a sufficiently large quantity to determine what he is doing. Of course, I could imagine that the use of known materials is taken for granted. The Navy Yard has probably had a large amount

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* American Manganese Bronze Co.

materials of known compositions; that is where it had a great advantage, because the average small foundry man who will go out and purchase scrap materials of unknown composition and mixed badly certainly can not get such uniform results. Of course, the author melts his metal twice. He first applies intense heat, after which the metal is analyzed in order to determine composition, and then, after his composition is known, he remelts it. This, if done carefully, would undoubtedly give him a uniform composition of the bronze. We have not found that large percentages of manganese result in a weakened alloy; we have used manganese up to 5 per cent. without losing any dross or oxides in our castings. That is European practice also. In France and England (and I have had occasion to examine some samples from Germany and Austria) these bronzes are frequently high in manganese. In fact, some very difficult castings in submarine and torpedo-boat destroyers and air compressors ran high in manganese. Castings that had to carry an air pressure of 3 lb. per in. carried high manganese, so that I am inclined to differ with the statement that high manganese is inconsistent with clean, sound castings.

P. E. McKinney.—With reference to the question of tests, I might say that you have seen the specimens passed around the room which are cut from rather heavy castings cast in sand, not against a chill. It represents a dry sand casting, a most difficult casting on which to get high physical values, on account of the extremely slow cooling.

With reference to taking tests out of the body of the casting, I feel that, so long as the shrinkages are right on the casting proper, a cut taken anywhere in a casting will be representative of the metal in an attached coupon not covered on a chill. That will hold in aluminum bronze, manganese bronze, steel, or any other metal that has a high shrinkage. We are frequently called upon to take tests for information from the casting proper, in which case I do not hesitate to remove a test piece from the castings by the hollow mill. As a matter of fact, I would just as soon accept the test piece obtained with a hollow mill as I would that from an attached coupon.

With reference to size, I have made quite a number of castings weighing up to 9.5 tons with this metal; I do not know whether there are any heavier ones. These castings, moreover, are in service and have stood rather hard service during the war in torpedo practice.

The objections to manganese and aluminum as ingredients, of course, might depend on whether you use new metal or scrap, because usually the commercial grades of manganese bronze have added to them quite a percentage of aluminum and manganese. But our experience has shown that, for a casting alloy, aluminum and manganese are very beneficial in giving toughness and strength, without necessitating an increase of the zinc content.

WILLIAM CAMPBELL,* New York, N. Y.—I would just like to confirm what Mr. McKinney has said about test specimens taken from the casting itself. At the Brooklyn Navy Yard we have found that the test specimen taken from the casting gives just as good results as that cut from the coupon attached to the casting. As he says, the question of strength is a question of foundry practice. When the foundry tries to skimp on the metal and when sufficient head is not used for shrinkage the metal falls down. The test specimen shows cracks through practically its whole length; and under the microscope you will find that the crystals do not properly cohere. When the metal is poured right, at the correct temperature, etc., the test specimen from the casting will practically agree with that from the attached coupon.

With regard to composition, it seems that you can get equal strength and ductility, whether you are dealing with high or low manganese and iron, high or low aluminum, and up to a certain per cent. of tin. The same holds good for the amount of lead at least up to 0.25 per cent.; apparently lead does not have much effect on the strength as long as it is in the form of fine well distributed globules.

The conclusion we have come to is that the melting and foundry practices are the two great factors in manganese bronze and that in nearly all cases of failure it was found not to be the trouble with the composition as much as that arising from included dross and from shrinkage, during the period of solidification.

J. B. F. HERRESHOFF, New York, N. Y.—Nothing has been said about antimony, which, as we all know, is bad in copper, especially in copper used for brass. The results are very bad. There is just the possibility that in the use of scrap, unless some change is made, we might find some hard lead. In that case, we might have brass of very low strength. We do know that if there is even a trace of antimony in the copper the resulting brass is not ductile.

I see no reason why cartridges should not be made from brass where scrap is used; if the scrap comes from the high grades of copper that all the firms are putting out now. Electrolytic-copper scrap, and scrap of that sort, ought to be perfectly satisfactory; and with proper production the brass ought to be sufficiently pure for cartridges.

WILLIAM HAMILTON,† Newport News, Va.—Just one word to substantiate some of the statements made by Mr. McKinney. I have seen his work and know that he has made as fine castings as I have seen. My firm made the very same experiments as Mr. McKinney has described and found that a great deal depends on the foundry practice. Unless

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* Professor of Metallurgy, Columbia University, and Metallurgist, Navy Yard, N. Y

† General Foreman, Iron, Brass, and Steel Foundries, Newport News Shipbuilding and Dry Dock Co.

manganese bronze is gated at the bottom, you will not get pure metal, but will be sure to get a dirty casting. In one case, which Mr. Clamer is well acquainted with, we went through a great deal of experimenting to get good test pieces and found that the test piece on the bottom of a casting did not give any better elongation or reduction of area than one taken from the bottom of a riser. The riser was on the top of a casting weighing 15,000 lb., the riser was 3 ft., outside diameter, and the inside 14 in. When the test piece was taken from the riser, we got almost the same result as from the coupon attached to the very bottom of the casting, which was about 6 ft. from the top, with that much pressure on it. As Mr. Clamer said, there are a great many things we have to do for the Government that the Government does not do for itself; a great many things pass in its foundries that would not pass in ours. Consequently, we have to take tests from different parts of the castings.

As to the ingredients, I have tried this manganese bronze, getting the zinc from our own galvanizing plant, and after analyzing have found that I made just as good manganese bronze as Parsons could sell us. We have just as good manganese bronze out of all scrap, with the exception that the elongation is nearly always a little lower. Compared with the tensile strength, Mr. McKinney's elongation is a little lower. That is the only difference I have found. We made the bronze in crucibles, never in a reverberatory furnace. I have made tons of it and put it into castings and propellers, and I have yet to find it to fail.

HENRY TRAPHAGEN,* Toledo, Ohio.—Mr. McKinney's valuable paper has shown us that the material commonly looked upon as worthless junk can be made into not only usable, but really good material. His results form a remarkable demonstration of the application of the three great requisites of successful metallurgical practise; viz., patience, horse-sense and elbow grease.

You will note one significant remark: "If the material is properly melted, I can obtain excellent results." He might have added "even from junk." Careful melting coupled with common sense is the open sesame to the reputation of some of our most successful firms, and the lack of it, the reason for countless failures. It makes no difference whether the product be manganese bronze, high brass, steel or iron, the best materials, carelessly melted, spell failure, while poor material, properly handled, will often give excellent results.

It really seems to me that we spend a great deal of time spinning fine theories and gazing into microscopes, when we might well give a little attention to the man on the job, and the way he handles the furnace. Perhaps it is not scientific, probably it does not agree with our ideas of

* Metallurgist and Chemist, Toledo Steel Castings Co.

dignified discussion, but I have no hesitation in stating, and a fair share of experience has proved it, that 95 per cent. of foundry troubles are directly traceable, not to abstruse scientific causes, but to plain every day carelessness. For instance, about a year ago, a certain foundry made heat after heat that failed in reduction of area. Numerous experts were consulted and the opinions given would have filled a book, but still the heats continued to fail. Microscopic examinations and chemical analyses were made almost without number and without a solution of the problem. It was then decided to use horse-sense and make the men use elbow grease. The same raw materials were melted, but the metal was held under a protective slag until quiet; it was then tapped into the ladle and held for 10 min. before pouring. The molds were carefully cleaned and kept clean, and a large riser was placed over the test bar. From that day and until the end of the war, that firm did not have a single failure. Yet the same raw materials, the same furnace, the same pattern, the same annealing methods were used; in fact, nothing was changed except the method of handling.

Pig metal and scrap are always dirty and more dirt is gathered from the furnace and from the molds, and unless the metal is allowed to remain quiet and clear itself, failure is almost certain. Mr. McKinney has shown the way. Refine hot, pour cool into clean molds, after holding the metal for a reasonable time, and many of our knotty problems will disappear.

Metals and Alloys from a Colloid-chemical Viewpoint

Discussion of the paper of JEROME ALEXANDER, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 427.

JEROME ALEXANDER.—All of you undoubtedly know that a microscopic examination of metals will reveal many things; but we should go further than just simply using a low- or medium-powered microscope and seek the reason why grain size varies under different conditions. When we get below the limits of the ordinary microscope, we enter the so-called colloidal field, which means that we are dealing with aggregations of matter that approximate, say, 100 millimicrons. The colloidal dimensions average approximately 50 millionths of a millimeter and extend down to about 3 $\mu\mu$. This, of course, is beyond the range of visibility in the ordinary microscope. Just to give you an idea of this matter, if 1 cu. in. of platinum is reduced to a sheet five molecules thick, it will cover 7 acres; you can imagine the amount of surface involved when metal, or anything else, is subdivided to so high a degree. Of course five molecules thick is a little below the limits of the colloidal dimensions.

The statement is made in the paper that "metals and alloys might be

regarded as jellies and sponge-like structures." Of course that is not absolutely true, because, at certain stages, metals are rather aggregations of crystals surrounded by some kind of a matrix. But when metals or alloys are chilled suddenly there is not the degree of crystallization ordinarily found in the ordinary commercial metals.

It is very difficult to make examinations in masses of metals. About 9 or 10 years ago, I did some work showing the effect of colloidal substances, such as glue, etc., on the crystallization of ordinary salts, like sodium chloride, etc. If ordinary sodium chloride is mixed with a small per cent. of gum arabic and allowed to crystallize, the most interesting branching forms are obtained, which at once reminded me of a great many of the so-called crystal forms seen in the photomicrographs of alloys. It appears that wherever there is a crystallization tendency it is possible, by the presence of other substances, to modify that tendency so that the final result is something between what the metal or the salt would have done had the influencing substances been absent, and some other extreme, which has not yet been determined. In any event, crystallization is very powerfully influenced by other substances. Now, whether the action is physical or chemical, or whatever you wish to call it, the fact of the matter is that wherever an ordinary salt, like sodium chloride, starts to crystallize, you can influence its whole crystallization by adding to it a little gum arabic or similar colloid.

It seemed to me that a similar condition must be true in metals. I have not delved into the whole question of metals; I know very little about them, but the analogies are so strong that it seems a very promising field of investigation, and the only difficult question is the preparation of the proper samples of investigation so as to go further than just using the ordinary microscope on the metals. We should see whether we cannot get some information by means of an instrument that will render visible particles smaller than are shown by the ordinary microscope. You might raise the question, are these particles crystalline particles or not? My answer to that would be that I do not believe we can ever know with absolute certainty. Since they are smaller than a wave length of light, they never will have any apparent size or shape; they simply will vary in brilliance and in apparent size. Consequently, the particle itself can never be resolved, although it may be made visible. There is a big difference between visibility and resolvability. Besides, substances like glue and gum arabic have the power not only of altering crystallization but of preventing crystallization. There must be an analogous condition in the case of metals and, from simply glancing through the metallurgical literature, I have seen numerous cases which point to that very fact.

As an illustration, I have some samples of transparent soap that were prepared about 9 or 10 years ago. Transparent soap has, in a way, some

peculiarities that offer a strong analogy to metals. A piece of this soap was melted in a pot over the kitchen stove and one part was cooled relatively slowly; the other part was cooled off quickly. When examined with the ultra microscope, the one that had been chilled very quickly showed practically no ultramicrons; it was, practically speaking, homogeneous. The piece that had been slowly cooled showed a large number of ultramicrons. When examined about 3 or 4 years later, no ultramicrons were visible in the quickly cooled piece, which was apparently as homogeneous as before, but in the slowly cooled pieces there were crystals visible under low power. There is also a big difference between the two pieces of soap even today.

PAUL D. MERICA,* Washington, D. C. (written discussion†).—The study of the effect of degree of dispersion of solid solutions in alloys seems to hold forth most interesting possibilities. Until recently only one example of an alloy solution of varying dispersion of the solute was well known to metallurgists; that of cementite (Fe_3C) in alpha, or perhaps in alpha plus beta, iron. According to one theory of the hardening of steel, the changes taking place during the tempering of steel are due to the progressive coalescence of this cementite from particles of almost atomic size, in martensite, to colloidal particles of larger size in troostite and sorbite, and finally to particles of size sufficiently large to be visible under the microscope, in granular pearlite. As the average size of particle of cementite increases, the hardness of the conglomerate diminishes and the electrical conductivity increases.

I have recently studied another alloy series in which also a solid solution occurs, apparently in different degrees of dispersion. This is the binary system: copper-aluminum, in which a solution of approximately 4 per cent. of copper as $CuAl_2$ in solid aluminum is formed at about 500° C. The solubility of the $CuAl_2$ in aluminum diminishes with decreasing temperature; consequently such an alloy, when quenched from 500° C., is supersaturated with respect to $CuAl_2$. During the tempering of the quenched alloy at about 200° C., as all evidence seems to indicate, the excess particles of $CuAl_2$ coalesce just as do those of cementite, forming progressively larger and larger ones.

Just after quenching, when the solution is still presumably in atomic dispersion, it is quite soft, as the coalescence progresses during tempering, the hardness first increases to a maximum and then diminishes again. There is apparently a certain degree of dispersion which produces maximum hardness in this solution, one in which the particles are greater than when in atomic dispersion.

It is to be hoped that the introduction of the use of the ultra-violet microscope and of the x-ray diffraction "microscope" for the study of

* U. S. Bureau of Standards.

† Received Feb. 26, 1919.

the structure of metals and alloys may make possible further systematic study of the effect of degree of dispersion upon the physical properties of solid solutions.

Standards for Brass and Bronze Foundries and Metal-finishing Processes

Discussion of the paper of LILLIAN ERSKINE, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 263.

JESSE L. JONES,* Pittsburgh, Pa.—I would like to ask Miss Erskine if down-draft has been used in any of the foundries where heavy fumes have to be removed, instead of the overhead draft?

L. ERSKINE.—The system of overhead draft to remove heavy fumes has been very much more successful. The entire efforts of the New Jersey Department of Labor in regard to stabilizing conditions in the foundry are the result of the physical examination of the foundryman himself on first-hand information as to the prevalence of the minor ailments and the bad timekeeping that naturally accompanies them. These ailments are a factor in not only increasing the labor turnover but in increasing the percentage of bad work as well. The physical exertion of the foundryman himself is of course an important factor. In certain standard shops the amount of energy expended runs from 11 to 13 tons of foot-pounds of energy a day. In certain shops on piece work, I found a record of the energy expended per day to run as high as 22 tons. In one shop, during the war period, the management established a bonus system, and the men increased their output from 60 to 100 molds a day. The result was an increase of some 60 per cent. in output, and an increase of 400 per cent. in defective castings.

The question of the physical exertion in the unsanitary foundries, of course, is very much complicated by other factors, for which reason the department has devoted a good deal of attention to estimating what is a reasonable exertion in a sanitary, well ventilated foundry. We have met certain physical difficulties in the brass foundries that the iron foundries did not have. All that information is available through our Bureau of Industrial Information. The question of the physical energy exerted by the molder is found to have a very distinct bearing on the question of contracts, for the possibility of increasing production is balanced by the extra overhead involved.

JESSE L. JONES.—I would like to ask if any evidence has been noticed of carbon-monoxid poisoning among the employees of the foundries.

L. ERSKINE.—I have had some very interesting cases of carbon-monoxid poisoning among the employees. These, however, were due

* Westinghouse Elec. & Mfg. Co.

to an incidental condition, which was rapidly corrected. But we have all had the experience that during the last 3 years the procuring of material and men, and the general question of upkeep is not on a standard basis, so that in many instances the question of establishing a natural ventilating system, by even so crude a method as knocking out a section of the wall, has been necessary. In some instances this has produced much more satisfactory results, I must admit, than some of the mechanical ventilating systems that have been devised by inexperienced engineers.

G. H. CLAMER,* Philadelphia, Pa.—I should like to ask Miss Erskine if there have been any installations directly connected with the molds, for exhausting the atmosphere, as compared with exhausting the entire atmosphere of the foundry? In the foundry with which I am connected we pour our molds, as they do in most foundries, over the whole floor and a great many of our alloys are of very high content; therefore it would be very desirable if we could get some means of exhausting the atmosphere just at the point at which the metal is poured. We have never been able to figure out an arrangement that has been satisfactory.

L. ERSKINE.—To install a ventilating system directly over the pouring flow has proved very satisfactory. It has been done by dropping a metal curtain, which practically surrounds the pouring area; and by installing an auxiliary fan in the monitor, it has been found that the fumes are readily started in the direction desired. The trouble with most of the monitors is that they have been used for lighting purposes, and that where the width exceeds 20 per cent. of the foundry's width, they have given unsatisfactory results. Dropping the metal curtain, with a narrow enough monitor in which the windows are properly regulated, I think will give very satisfactory results.

Results of Cement Plugging for Exclusion of Bottom Water in the Augusta, Kansas, Field

Discussion of the paper of H. R. SHIDEL, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 142, October, p. 1613.

MOWRY BATES,† Tulsa, Okla.—In the first part of this paper the author says: "In an unpublished paper on Water Problem in the Augusta Field, S. K. Clark reaches the following conclusions: (1) That the great amount of water present is bottom water, occurring in the Varner sand, the main producing or the 2500-ft. horizon. (2) That the only striking connection between structure and water is in the area of the marked

* First Vice-president and Secretary, Ajax Metal Co.

† Petroleum Geologist and Engineer.

fault on the Ralston, E. C. Varner, and F. Varner leases in sections 8, 9, 16 and 17."

That paper must have been written a long time ago because practically all of the producing wells are in water now and were on structure, that is on the sides of the numerous domes found in the El Dorado and Augusta fields. They are now practically all making water and the water occurs in the lime where the oil is mostly found. The oil is forced out by a hydraulic flow, there is no gas in the producing zone at all. The lower wells strike water first; the ones highest up on the structure will make entirely oil. As the oil is taken out the water flows up the structure. The Shumway lease, of which I suppose you have all heard, has produced up to date enough oil to fill a tank ½ mi. square and 7 ft. deep from the porous lime formation, which is more oil than the lime usually contains. That lease is practically all water today and I do not see how they can shut the water off by plugging.

EUGENE COSTE,* Calgary, Alta.—My experience is that in many cases you cannot avoid the water. If the water is in the sand itself, the only thing you can do is not to drill too deep into the sand. If you have drilled too deep, sometimes it is possible to plug the bottom water and in that way so minimize the trouble that the water becomes an advantage, for a little water is really an advantage.

There are two main things to avoid in these water troubles: First, the water from above, to avoid which one must be sure that the casings are tight and set at the right depth; they should be cemented if necessary before drilling into the oil sand. That is an easy thing to do with a little patience and care. Second, the most important thing is to avoid water trouble from the outside of the field. This outside water comes from wells beyond the pool, in the dip mostly, but sometimes not in the dip. The state should intervene on those wells that are just water wells, and should compel the operators to plug a well before abandoning it. The operators themselves inside the fields will easily overcome all the other water troubles which will not affect the total production of the field. Although certain particular leases may get too much water as the oil becomes exhausted, yet the field as a whole will not be affected.

MOWRY BATES.—About two weeks ago we asked some of the operators in the mid-Continent field who had been plugging the wells, what the effect had been. They said the production was increased for a very short time. But it seems to me that if this oil is produced on an anticline, and it is pretty well established now that it is, and as the pressure is practically hydraulic pressure at the rate of 0.4 lb. per foot of depth except in a very few cases of synclinal oil, as fast as you extract the oil the water must ascend. As for plugging a well, you only plug about 7 in. and

* President and Chief Engineer, Canadian Western Natural Gas, Light & Power Co., Ltd.

generally there are about 6 acres around each well through which water can pass. You cannot stop the ascent of the water.

When you take out the oil, the water is going to follow. You can plug an individual well or a dry hole that is making water and save it for a very short time, but only for a short time. That is absolutely proved in the Cushing field, where some of the wells were plugged. The production was increased about 50 per cent. at the time, but it is down again and all the wells make just as much water now as before, though some of them were cemented over. This is true in all cases of the Bartlesville sand but some of the wells that were making water from the Tucker sand have been successfully plugged as there is a break between the sands.

A. W. AMBROSE,* Washington, D. C.—In California they had very good success in the Coalinga District and elsewhere by coöperation between the companies. As a result, in certain wells that were considered hopelessly gone to water, it was possible not only to shut off the water but to increase the production. When you consider that a driller can never pick up a break of a few inches unless the break has some characteristic feature, I fail to see how it would be possible to pick up a 3-in. shale break at a depth of 2200 ft. in a well drilled by a rotary.

MOWRY BATES.—While working for the Gulf company, I was authorized to stop a well and test it. I washed it out for about 2 hr., then moved the bit for 5 or 10 min., and then washed it again. It cost the company a lot of money, but I was trying at that time to get some samples for the Geological Survey.

A. W. AMBROSE.—Another way is to put a core bit on the bottom of your rotary drill pipe; otherwise, I do not see how, when you wash, where you have 2000 or 3000 ft. of open hole, you are going to pick up such a small shale break, as the shale above may cave in and show in the washings. Take the Eldorado Augusta case: Many of the companies have no record but the thickness of the oil sands. They do not know, for instance, whether in the 50-ft. producing horizon there are one, two, or three breaks or one unbroken producing horizon. The companies there have everything to gain and nothing to lose by coöperation, which has proved very successful in California. In the Kern River field, some wells were producing as high as 15,000 bbl. of water per day by the aid of air compressors in order to get 40 or 50 bbl. of oil. Some of these compressors must have cost anywhere from $200,000 to $300,000. When the compressors were first used, operators lifted a small quantity of water; then the flow of water increased as the flow channels in the sand opened and soon the old compressors had to be replaced for newer and larger ones. By coöperating and spending

* Petroleum Technologist, U. S. Bureau of Mines.

about $5000 to trace the source of that water and connecting one well, it was possible to junk several thousand dollars worth of compressors.

I. N. KNAPP,* Ardmore, Pa.—My experience is that it is bad practice to wash out a well at any particular point to determine the formation. It is extremely difficult in rotary drilling to get reliable samples of the material as it is passed through. If clear or turbid water is used, the cuttings tend to dissolve or separate by the jigging action of the ascending circulation, and the heavy particles tend to lodge in the irregularities in the walls of the well between the end of the casing and the bottom of the hole. In such cases it is very difficult to find any material in the overflow from which to judge of the formation through which the drill is passing. If a heavy mud is used there is much less dissolving, separating and mixing of the drill cuttings, and on washing out a sample from the mud overflow, particles may be found that fairly indicate the material just drilled through.

If you wish to get an accurate well log with samples of an unconsolidated formation at any particular horizon with the rotary it is necessary to take a core. This is a pretty hard proposition but I have accomplished it. I have taken out as much as 12 ft. of core at a time. It is difficult to get a soft core out of the core barrel and lay it out on the ground without considerable breakage, but I did get some pieces 2 and 3 ft. long. The material was very friable and easily broken with the fingers.

I have been told of a device that has been in practical operation in the Baku, Russia, oil field for some time that will pick up an accurate sample of the formation from the walls of wells drilled in unconsolidated formations at any selected point between the end of the casing and the bottom of the well. Such a device is greatly needed in this country.

I have had top and bottom water troubles in fields where the oil sands themselves were saturated with oil only and this without a trace of water. If the top water in such cases was efficiently shut off in the first place there was no future trouble. The bottom water after once being definitely located could not cause trouble unless deliberately drilled into. We have heard a great deal about water in the same sand with the oil and of mudding and cementing this afternoon but no reference has been made to Texas and Louisiana conditions and practice. What has been said does not seem to agree with the practice down there.

MOWRY BATES.—I would like to return to what Mr. Ambrose has said. I cannot see why plugging one well is going to shut off 6 or 7 acres of sand. It will shut off the water up to the level of the oil, but as the oil comes out the water comes up.

A. W. AMBROSE.—We are arguing on different points. You are assuming that the water occurs in the oil sand while I am assuming that it may not be.

* Mechanical Engineer.

MOWRY BATES.—It is in the mid-Continent field.

A. W. AMBROSE.—That same thing was contended by the oil operators in California until they were shown that there was a separation between the oil and the water sands. When they plugged off the water, they found there was a break that had never been considered, and the point is whether or not similar conditions hold in Augusta.

MOWRY BATES.—I do not think they do.

I. N. KNAPP.—A bulletin recently issued by the Smithsonian Institution[1] contains a section on petroleum and a section on natural gas. The writer of the petroleum section claims that so long as the ownership of oil in the ground is determined by vertical property boundaries, arbitrarily dividing a geologic unit or reservoir into many parts, just so long will there be hurried production with all its train of waste and losses. The writer of the natural-gas part claims gas-field operating conditions should be regarded as a natural monopoly and that it is a primary need of the industry to have mandatory pooling of field operations, coupled with an adequate market price.

It would be a fine thing for the operator to individually control all the land in any one oil or gas pool or reservoir. It would ultimately result in the landowner getting more royalty and in the conservation of both oil and gas and also lower the cost of production. I am fearful that all the oil and gas in our country will be exhausted before such conditions can be brought about.

EUGENE COSTE.—The great trouble of water in the oil and gas fields is due to the careless man, the one who wants to pull out his casings and sell them, or the one who relies too much on the drillers and does not assure himself that the casings are properly set in the right place, and properly cemented when necessary. A careful operator will take the necessary precautions to have his casings right but when a careless man on another lease does not case off properly, he communicates the different water sands with the oil sand either from above or below. I think the sands from above are especially dangerous. When a man pulls out all his casings and does not have his well properly plugged, the greatest danger is from the fresh water sands. The fresh water from above is the most dangerous because it gets the weight of the thousands of feet between the surface and the oil sand, which can often easily overcome the pressure in that sand.

I entirely agree with the gentleman who recommends coöperation among the operators, but would include also coöperation and regulation by the state—regulation by an authority that can make the operator give

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[1] See Smithsonian Institution, United States National Museum, *Bull.* 102, Pt. 6. Petroleum: A Resource Interpretation; Pt. 7. Natural Gas: Its Production, Service and Conservation.

the proper information to the inspector so that he can do his work intelligently. If that is done, it will save millions of dollars worth of oil.

Even after a field has been used for many years, no strong hydraulic pressure is found to interfere with production. We know that absolutely because gas fields with original pressures of, say, 1000 lb. have had very little trouble with water, when the proper precautions were taken, even when the pressure had declined to 50 lb. in the field, and even down to nothing.

THE CHAIRMAN (DAVID WHITE,* Washington, D. C.).—The use of the terms "primary" and "secondary" as incorporated in this paper tends to create confusion on account of the use of the terms in the discussion of the chemical composition of oil-field waters. However, in attempting to suggest substitutes, one encounters the difficulty of length and cumbersomeness of such substitute terms as indigenous or autochthonous, but he might use foreign and native waters.

I feel that the studies which have been made from the chemical standpoint of the oil-field waters—G. S. Rogers is carrying on such studies now—tend to show great value in the analysis of the waters with reference to detecting their origin. Top waters, such as those described, should be readily identified by their analyses.

Natural-gas Storage

Discussion of the paper of L. S. PANYITY, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 145, January, 1919, p. 23.

L. S. PANYITY.—I made inquiries from the Smith and Dunn people, who are the originators of the compressed air and gas method of increasing the production of oil wells, as to how much pressure the sand will stand; that is, relative to the original rock pressure. They tell me that they have not been able to show, up to date, any pressure in a sand greater than the original pressure. I have also made a statement to that effect, but I am really dubious as to whether that is right, as I am not sure that you cannot get a greater pressure. However, I think that a greater pressure would be dangerous because it might cause a loss of gas.

C. H. SHAW,† Lawton, Okla.—In regard to the gas that was put into the pool up in New York State, may it not be possible that, on account of errors, etc., in measuring or computing, there is a mistake in the apparent fact that more gas was gotten out than was put in?

L. S. PANYITY.—Unfortunately, I have not the papers I expected from those people to show the actual conditions, but I do not doubt that such

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* U. S. Geological Survey. † Attorney-at-Law and Petroleum Engineer.

an error might exist. It is possible that the renewed action and pressure in the well might have caused some sort of commotion there that produced a little more gas than was obtained before.

THE CHAIRMAN (DAVID WHITE,* Washington, D. C.).—The New York storage was limestone.

L. S. PANYITY.—It was limestone; they call it a flint rock, though, I believe. It is in the western part of New York and is on a dome structure called flint field. They have no other name for it.

CHAIRMAN WHITE.—Was the gas measured at the storage well both going "in" and "out?" Assuming that your well storage is in a different sand from that producing your gas, did you ever make an analysis of your incoming and, again, of the outgoing gas, to show what difference there might be?

L. S. PANYITY.—I have not obtained those figures.

EUGENE COSTE,† Calgary, Alta.—I am glad that this subject has been brought before the Institute, because it is a practical subject; I have used such a storage in exhausted sands for many years with success. The Welland field in Ontario is 30 years old, covers a large area, and the gas sands are close-grained sands. Parts of the field have exhausted because the gas was first obtained in these parts and the wells have been used constantly for 30 years. In the newer parts, where we got the gas later, we had a stronger pressure. For years, in the summer time, when we did not require high-pressure wells, we turned the gas into low-pressure wells and know that we have obtained a larger quantity of gas in the winter time by that method.

This method was suggested to me by the action of a well south of Buffalo, which we used to call Big Zoar Well. It belonged to the United Co. piping gas from Pennsylvania to Buffalo and was close to their main line. The gas was in a limestone, filled with flint of the Corniferous formation. It was a large well, 15,000,000 cu. ft., but it would get down to about 800,000 cu. ft. after a few days of use. As it was very much nearer Buffalo than the main supply in Pennsylvania, this well was kept closed in until we had a long cold spell causing gas pressure to drop too low. Then the Big Zoar Well was turned in and it would help the Buffalo Company to get over the cold spell nicely. Immediately the pressures picked up again the company would close the well in. In that way it was found that this well was a splendid storage and was worth hundreds and thousands of dollars to that company. That gave us the idea of doing the same thing, using the storage in the Canadian field of the more or less exhausted parts of the field. For years now, we have transferred gas from one part of the field, which was under pressures of say, 300 lb. to

* U. S. Geological Survey.

† President and Chief Engineer, Canadian Western Natural Gas, Light & Power Co., Ltd.

another part under pressure of 100 lb.; also from 3000-ft. wells where gas was obtained into another limestone, the Trenton, where we had 1000-ft. pressure. These we often kept feeding in the upper rock. We measured the wells and know that after thus feeding in them for a while the low-pressure wells would recover a great deal and that instead of measuring 200,000 to 400,000 cu. ft. they would measure up to 1,000,000 cu. ft. or more. In that way we were in better shape to meet the cold weather the following winter. It wouldn't be surprising if by that method one could obtain a little more gas from the low-pressure part of the field than would otherwise be possible. I mean of its own gas, of the gas belonging to these parts of the field, because in that way the gas has a chance to flow under higher pressure, or compression, for a longer period. Everybody knows that as the pressure goes down, the friction increases, so that where the gas couldn't travel at all and enter the well under the low pressure, by building the pressure around that well up to, say, 200 lb. the gas will come in, because the friction will be less at the higher pressure. In that way, not only will one recover all the gas put in, but some that could not be gotten otherwise.

L. S. PANYITY.—There may be some difficulty in getting the land needed for such purposes. There is no doubt that it will be a hard thing to do with three or four operators in a certain field, without their coöperation. Besides, it will be hard to acquire the land if the owners know what you want to use it for. I think, however, that difficulty can be overcome for a small fee, or by the promise to the owner of a certain amount of free gas.

I. N. KNAPP,* Ardmore, Pa.—I believe the free-gas conditions of a lease should have some definite limit. Unconditional "free gas" leads to abuses and great waste. For lease or other considerations, as rights of way, it should be limited to amounts to be determined by meter measurements or by specifying the number of gas lights allowed and if for fuel use by specifying the number and size of the mixers allowed.

Economic and Geologic Conditions Pertaining to the Occurrence of Oil in the North Argentine-Bolivian Field of South America

Discussion of the paper of STANLEY C. HEROLD, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 141, September, 1919, p. 1503.

EUGENE COSTE,† Calgary, Alta.—Evidently in Argentine they have a petroliferous province just east of the Andes where very much the same conditions exist as are found on the east side of the Rocky Mountains

* Mechanical Engineer.

† President and Chief Engineer, Canadian Western Natural Gas, Light & Power Co., Ltd.

and in the plains adjacent. It strikes me, though, that the same mistake is being made in Argentine in the exploration for oil as was made in Alberta, Canada; viz., drilling the wells too near the seepages in the belt in the eastern part of the petroliferous province, too near the mountains. This same mistake was made in Alberta, with disastrous results; viz., only fissure production was found. The strata so near the mountains are tilted at a very strong angle, such as is described in this paper, and the dislocations are intense. On the other hand, we have found that when we get 100 or 200 mi. away from the mountains we get into oil and gas belts which are very prolific. So far our fields in Alberta have been gas, but in Wyoming, as you know, they get many thousands of barrels a day. I have no doubt that conditions in Argentine are exactly similar but that they have so far kept too near the mountains and that they want to explore the belts farther east to obtain better results.

MOWRY BATES,* Tulsa, Okla.—In Oklahoma we have a very similar condition; in the southeastern part of the state there is a decided uplift with highly folded and faulted country. In this we have the Fort Smith gas field of Arkansas where you get only gas. To the east of this field are the great areas of asphaltic sandstone; some distance to the west there are indications of oil and to the northwest are the oil fields. This would indicate a partial distillation in the ground. This is fairly close to the original oil field which bears out your statement.

EUGENE COSTE.—May I refute that idea of partial distillation? I thind it can easily be proved that there is no such thing as partial distillation. Taking Alberta, for instance; in the deep syncline we have many regions absolutely undistilled but full of gas. There never was in these strata heat enough to cause the slightest distillation as shown by the coals and lignites in these strata which are entirely undistilled.

Effect of Cold-working and Rest on Resistance of Steel to Fatigue under Reversed Stress

Discussion of the paper of H. F. MOORE and W. J. PUTNAM, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 391.

JAMES E. HOWARD,† Washington, D. C. (written discussion‡).—It is a pleasure to participate in the discussion of a paper on the endurance of steel to repeated alternate stresses. For many purposes the prime and only function of the metal is to resist strains and stresses: stresses of long duration in one direction only; stresses that alternate between a maximum and a minimum in one direction; and stresses of different de-

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† Engineer-Physicist, Interstate Commerce Commission. ‡ Received Feb. 8, 1919.

grees in reversed directions. Such stresses represent some of the conditions that steel must meet in service, tests upon which furnish data of unusual interest and importance.

Experimental research has been directed more commonly upon reversed stresses than upon those acting in one direction. The ease with which reversed stresses may be applied to experimental bars has probably influenced the manner of carrying out this class of tests. In

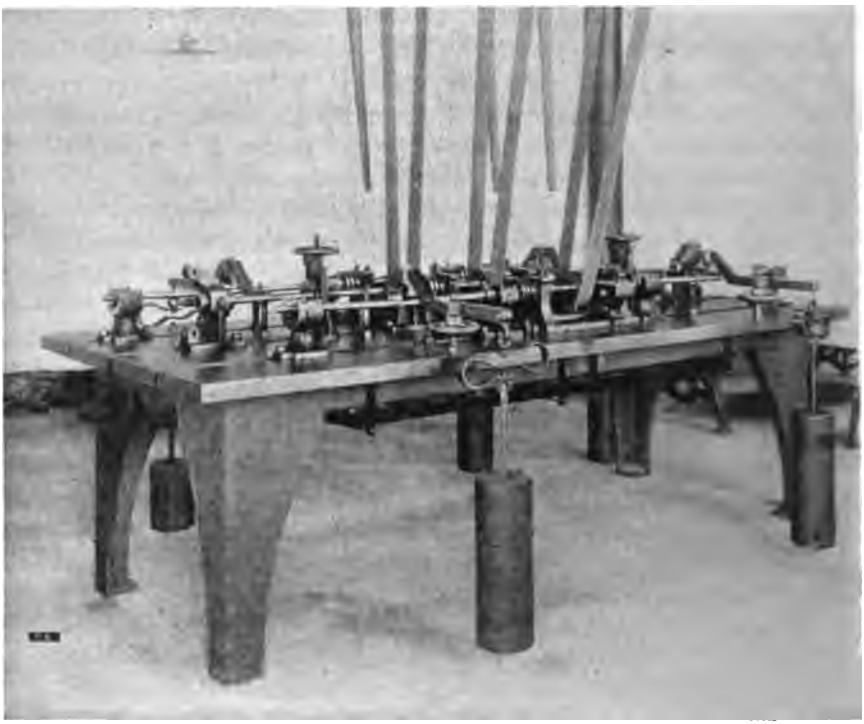

FIG. 1.—REPEATED STRESS-TESTING MACHINE DESIGNED BY J. E. HOWARD, USED IN THE INVESTIGATION TESTS MADE AT THE WATERTOWN LABORATORY, 1892–1908. VIEW OF THE MACHINE WHILE IN OPERATION, FOUR CYLINDRICAL BARS, 1 IN. DIAMETER BY 35 IN. LONG EACH, UNDER TEST. MIDDLE SPINDLE AT REST.

general, it has been convenient to apply reversed stresses in such a manner that the strains of tension and compression have the same values.

Repeated stress tests, approaching some of the conditions of service experienced by steel, occupy an advanced position in laboratory tests on the physical properties of materials. They aid in showing the absolute and relative values of different steels under certain conditions of service, relations that ordinarily are not established by tests made under specifications governing the acceptance of the material.

The endurance of steel of high stresses, in one direction only, of long

duration, seldom made the subject of direct test, is well illustrated in music wire. In the higher octaves of pianofortes of modern scales, the wires remain under constant tension considerably exceeding 150,000 lb. per sq in. (10,545 kg. per sq. cm.). Fatigue, as commonly understood, does not appear to be known in cases of constant loads acting in one direction, or but few examples have been met. The fractures of music wire usually take place where vibratory waves are interrupted. Without being called upon to do much mechanical work, steel under constant load is capable of enduring very high stresses.

Fatigue fractures are expected to occur when steel is employed in doing mechanical work. The amount of work that a steel bar will perform depends on the magnitude of the straining forces. High stresses lead to early rupture. The results of experimental research indicate that steels will endure certain lower ranges in stresses indefinitely; it remains for direct investigation to establish the upper limits of those zones within which the different grades of steel are practically indestructible.

Notwithstanding the fact that the chief function of most steels is to endure repeated stresses of some kind, very meager information has yet been experimentally acquired upon the ability of steel to endure the stresses of every-day occurrence. This information is needed to establish rational limits of loads on engineering structures. The primitive properties of steels are modified according to their chemical composition, and also by heat and mechanical treatment. It is generally assumed, but without warrant, that the primitive physical properties, however they may be attained, are indicative of the ability of the steel to endure service stresses of different degrees of intensity and of long or short duration. There are those who place reliance on the aid of the microscope and judge from the microstructure of the steel its ability to meet different service requirements involving strains and stresses.

The one physical constant that has been shown to bear a relation, standing as a limiting value, to repeated stresses is the elastic limit of the steel. It follows by no means, however, that it is safe to approach close to that limit; neither does it appear to have been ascertained by what means the elastic limit and other physical properties shall be acquired in order to best meet prolonged stresses. While the elastic limit is regarded as the upper limit of permissible stress, it is not certain on the one hand that the actual intensity of stress at the point of rupture by fatigue does not exceed that value, while on the other hand there are few, if any, engineering examples of any size in which local strains do not exist in excess of the elastic limit. Methods of test capable of furnishing direct data upon the fitness of the steel to endure service conditions must perforce include features to which the steel is exposed in service, and it may be permissible to add that probably reliable data must be obtained in this manner. The last part of the preceding sentence is

very sweeping since it carries the idea that tests adequate to show the ability of the steel to endure service stresses must be made in kind to the conditions that prevail in service.

In conducting tests having such ultimate objects in view, it is desirable to acquire information upon the phases through which the steel passes during exposure to stresses that finally result in rupture. Such considerations lead to a choice of apparatus in making the tests. Tests on repeated stresses conducted by the writer at the Watertown laboratory were inaugurated in 1888, impressing into service temporary apparatus. It was decided to use cylindrical shafts measuring 1 in. (2.5 cm.) in diameter by 33 in. (82.5 cm.) long in order to have a test bar of substantial size. For a certain length of time the test bars were loaded on a single bearing at the middle of their length. Later, an appropriation was available for a repeated-stress machine, designed by the writer, which was built and put into operation in 1892. This machine, shown in the accompanying illustration, was designed to accommodate four bars under one kind of test and two under another kind.

It was held desirable to use a double bearing for loading the test piece at the middle of its length, in order to apply a uniform bending load over a part of its length. From center to center of the double middle bearing, the distance was 4 in. (10 cm.). The grooved form of tensile test piece was discarded on account of objections to a form of specimen that had no length of minimum section. In a bar subjected to repeated stresses, it was considered even more desirable to have an appreciable length exposed to uniform bending stresses than a length of net section in the case of a tensile test piece. Prof. Sondericker, at the Massachusetts Institute of Technology, used shafts 1 in. in diameter, in which the loads, as described by Prof. Lanza,[1] "were so applied, that a certain portion, greater than 10 in. in length, was subjected to a uniform bending moment." Prof. Sondericker's investigations[2] included "the determination of elastic changes, resulting from repeated stresses, and the influence of such changes in producing fracture." Regarding the results, it was stated that "the effect of rest is to decrease the amount of set. In most cases, however, the set lost is soon regained, when the bar is again subjected to repeated stress, especially in the case of the harder steels."

For the Watertown laboratory equipment, a high-speed DeLaval steam turbine was procured, in order to conduct tests at speeds approaching vibratory movements; some 500 or more rotations per second. A rotating shaft appears to afford the only opportunity for conducting tests at high speeds in which acceleration of the mass of the specimen

[1] Gaetano Lanza: "Applied Mechanics," 534. New York, John Wiley & Sons, 1910.

[2] Jerome Sondericker: A Description of Some Repeated Stress Experiments. *Technology Quarterly* (1892) **5**, 70; Repeated Stresses. *Op. cit.* (1899) **12**, 5.

does not interpose as an obstacle to attaining a uniform distribution of the loads. High-speed tests conducted in this manner become introductory to tests on impact, and were so intended. There are two phases to be considered in tests on impact, one having to do with elastic movements not involving permanent sets, and one in which permanent sets are involved and constitute the major effects. The writer's severance of his connection with the Watertown laboratory brought these contemplated tests to a close. The testing apparatus was dismantled soon thereafter and it is believed has not been reassembled. The results of the Watertown tests are included in the reports entitled "Tests of Metals," 1888 to 1908, inclusive. These tests, a little over 400 in number, included cast-iron and wrought-iron bars, bars from muck-bar axle, bars from carbon-steel and nickel-steel ingots, cold-drawn and cold-rolled steel, ordinary hot-rolled steel bars in compositions ranging from about 0.10 to 1.10 per cent. carbon, bars from steel rails, and heat-treated bars. The fiber stresses employed ranged from 10,000 to 60,000 lb. per sq. in. (703 to 4218 kg. per sq. cm.). The tests were made at temperatures ranging from about freezing up to 700° F. (372° C.), with speeds of rotation from 400 to 2200 rev. per min. There were tests that were continuous, that is running the shafts day after day during working hours, and tests in which different periods of rest occurred; tests in which the same fiber stress was used throughout and those in which different fiber stresses were employed on the same shaft. There were also tests on bars that were annealed at intervals and nickel-steel bars, 3 to 5 per cent. nickel and those of about 27 per cent. nickel. Deflections and deflection sets were measured during the progress of the tests. The total number of repetitions of loads on the different bars ranged from a few thousand rotations to upward of 200,000,000. A subsequent examination was made of certain of the bars, after rupture by repeated stresses, to ascertain the effect of repeated stresses upon the properties of the metals, from sections, exposed to the maximum fiber stresses, adjacent to the place of rupture, and comparison bars remote therefrom.

Among the leading thoughts entertained in conducting these repeated stress tests were those concerning the manner in which rupture is approached: Through what phases the metal passes from its primitive state to that of final rupture; what features contribute toward increased life of the metal; whether the effects of repeated stresses are cumulative, eventually reaching that stage in which rupture is certain to take place; whether the effects of earlier stresses can be effaced and the life of the steel prolonged indefinitely by occasional annealing or other treatment whereby the steel is restored to its primitive state; to what extent internal strains are introduced and their manner of action; whether intense internal local strains are set up which eventually lead to the separation of adjacent particles and therefore start the nucleus of rupture; whether the actual

intensity of stress at such incipient places of rupture is represented by the apparent fiber stress carried by the bar, or whether rupture requires a local stress approaching the primitive tensile strength or shearing strength of the steel; whether microscopic evidence is presented of the approach to rupture in the fibers most strained; whether the influence of elongation and contraction of area witnessed in the primitive tensile tests is shown in the endurance of the shafts under repeated stresses, the greater endurance of the shafts at the higher testing temperatures taken in connection with the increased tensile strength of steels at 400° to 600° F. seeming to establish some relation between the primitive tensile strength and the endurance of repeated stresses. These and other thoughts suggested themselves in conducting endurance tests, attaching to matters which seemed involved or relevant to the subject matter. Many of these questions would have to be solved before it would appear feasible to write an equation that would be serviceable in indicating the behavior of steels when exposed to repeated stresses.

Laboratory tests afford opportunities not present in the service use of steels, in respect to control of conditions, whereby complete information is available concerning their endurance of repeated stresses. Elementary features associated with the use of steels in service admit of examination in detail in the laboratory. If features are recognized in the laboratory, which are precursors to rupture, it will give encouragement that a rational method of using steels in service may eventually be arrived at. One of the paradoxes of current engineering practice is the large amount of routine testing that is constantly going on under specifications that are ever changing, the results of which are remotely connected with the inherent value of the material to meet service conditions. Slight consideration has been given the effects of repeated or long-continued stresses under which failures occur, notwithstanding the fact that the profession has been in possession of data of this order for a long term of years.

J. B. KOMMERS,* Madison, Wis. (written discussion†).—So many questions regarding fatigue phenomena remain unanswered that information of the kind given in the present paper is very welcome. The authors are to be commended for the attempt to answer certain questions of the greatest practical importance. Tests on the fatigue of metals require a great deal of time for their successful prosecution, and the investigator knows before he begins that his results will come very slowly. It is evident that if mere cold working has a marked effect on fatigue strength, a very simple method would be available for producing the desired increase in strength. Again, if rest has a marked effect on fatigue strength, this fact could be easily made use of in a practical way.

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† Received Feb. 10, 1919.

It may be well to recall the results obtained by previous experimenters. Eden, Rose and Cunningham,[3] Rogers,[4] Boudouard,[5] J. H. Smith,[6] and Reynolds and Smith,[7] found that annealing steel specimens decreased their fatigue strength. The results of Stead and Richards[8] seem to show that annealing increases the fatigue strength. Rowett found, in some tests on the hysteresis of steel, that for hard-drawn tubes the hysteresis was only about one-eighth of that for the same tubes after annealing. This would imply that the hard-drawn tubes would probably withstand a greater number of reversals for the same applied stress. If, therefore, annealing seems to decrease the fatigue strength, evidently mechanical work during the process of rolling tends to increase the strength.

Referring to Table 2 and Fig. 2, attention should be called to the fact that for all stresses beyond the elastic limit the nominal stresses calculated are stresses that do not actually exist in the specimen. There is considerable evidence showing that the curve determined from these stresses and plotted on logarithmic paper is practically straight to about 1,000,000 reversals. There is also evidence showing that beyond about 1,000,000 reversals the curve tends to bend to the right. The curves drawn in Fig. 2 were all determined from results that were within 490,500 reversals, and for that reason should certainly not be continued beyond 1,000,000 reversals. This illustration makes clear the tediousness of determining such curves for large numbers of reversals. However, they can be correctly determined only by actual tests.

In some tests carried out by the writer on a machine[9] designed by himself and built at the University of Wisconsin, he found that when deflections of cantilever specimens were plotted on logarithmic paper against cycles necessary for rupture, a straight line resulted. These tests were all on specimens stressed beyond their elastic limits. Here again it would be of interest to know whether the straight line determined by these tests holds for deflections and, therefore, stresses within the elastic

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[3] E. M. Eden, W. N. Rose and F. L. Cunningham: The Endurance of Metals. *Proc.* Inst. of Mech. Engrs. (1911) Pts. 3 and 4, 839.

[4] F. Rogers: Heat Treatment and Fatigue of Steel. *Jnl.* Iron and Steel Inst. (No. I, 1905), **67**, 486.

[5] A. Boudouard: Testing of Metals by the Abatement of Vibratory Movements. *Science Abstracts* (1911) **14**, 98.

[6] J. H. Smith: Some Experiments on Fatigue of Metals. *Jnl.* Iron and Steel Inst. (No. II, 1910) **82**, 246.

[7] Osborne Reynolds and J. H. Smith: Throw-testing Machine for Reversals of Mean Stress. *Phil. Trans.* Royal Soc. London (1902) **A**, **199**, 265.

[8] A. W. Richards and J. E. Stead: Overheated Steel. *Jnl.* Iron and Steel Inst. (No. II, 1905) **68**, 84.

[9] See J. B. Johnson's "Materials of Construction," 71, New York, John Wiley & Sons, 1919.

limit. If this can be shown to be true, it will be of the greatest interest and importance, because it would make possible the determination of the number of cycles of stress necessary to cause failure at stresses within the elastic limit by the comparatively expeditious tests beyond the elastic limit. The writer is at present designing a machine for tests within the elastic limit, and he hopes to gather some information in an attempt to answer some of the questions just raised.

It may be well to point out that the straight lines determined from deflection-cycle curves are more likely to hold within the elastic limit than the stress-cycle curves, because the deflections actually exist in the specimen, but the stresses calculated by the other method do not actually exist.

A very significant thing in connection with Fig. 2 is that when all the straight lines are extended to the left they tend to coincide to a greater or less extent. This is borne out also by Table 2, in which it is shown that the material as received, with a low elastic limit of 44,400 lb. per sq. in. (3121 kg. per sq. cm.), can withstand 6100 reversals at a nominal stress of 70,900 lb. per sq. in. (4984 kg. per sq. cm.), while the stretched and aged material with a high elastic limit of 72,800 lb. per sq. in. (5117 kg. per sq. cm.) can withstand only 480 reversals at 62,200 lb. per sq. in. (4372 kg. per sq. cm.). If the artificially raised elastic limit of the stretched material has any real effect on fatigue strength, the material should be able to bear a fairly large number of reversals when stressed slightly below its new elastic limit. It cannot do this, which result is very significant.

One reason for this result may be found from experiments on static test specimens. It has been shown[10] that when a piece of wrought iron or steel is subjected to overstrain in tension, it loses its elasticity if immediately reloaded in compression, and vice versa. In the present tests the material was subjected to reversed stresses and a high elastic limit in tension would be of no value in compression. The results in Fig. 2, therefore, tend to show that the artificial raising of the elastic limit is fictitious as far as increased fatigue strength is concerned.

In Fig. 3, the two lines do not converge at the left side of the diagram as in Fig. 2. However, for the cold-rolled material it is seen again that at stresses slightly below the elastic limit the material cannot withstand very many reversals before rupture. These curves are very much like the results obtained by previous experimenters, and the fact that the straight lines converge to the right indicates that the advantage of cold-rolling may be only temporary, as Prof. Howe has suggested,[11] and may

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[10] Johnson's "Materials of Construction," 604–5, 661.

[11] H. M. Howe: Are the Effects of Simple Overstrain Monotropic? *Proc. Amer. Soc. Test. Mat.* (1914) **14**, Pt. 2, 35.

disappear at large numbers of reversals. It would be very desirable to have such tests carried out considerably beyond 1,000,000 reversals.

Comparing Figs. 2 and 3, there is unquestionably a difference. It may be that increasing the elastic limit by cold-rolling has some effect on fatigue strength, but that increasing the elastic limit by tension has none. In this connection I should like to ask whether the figures for ultimate strength after stretching, in Table 1, are based on the original area or on the area after stretching. Fig. 4 shows results such as are usually obtained in comparing annealed and cold-worked steel.

In the matter of effect of rest, Reynolds and Smith[12] found that rest from 3 days to 4 months did not increase the fatigue strength. Eden, Rose, and Cunningham[13] frequently stopped their machine during alternating-stress tests, sometimes for all night. They found that these periods of rest had no appreciable effect. J. H. Smith,[14] in experiments on stress-strain loops, found that during a period of rest steel which had yielded slightly and gave a stress-strain loop tended to approach the primitive condition during a period of rest, but that a comparatively few cycles of stress were sufficient to bring back the original loop. Mason,[15] in some tests of strain measurements during alternating stress, found that rest seemed to improve the material and decrease the strain for a certain stress; but that applications of stress again effaced this improvement. These tests all seem to indicate that if there is any improvement due to a period of rest, the improvement is only temporary and is soon effaced by further application of stress. The results of the present tests bear out the conclusion that very little can be expected from rest in increasing fatigue strength.

In connection with the White-Souther machine, I should like to ask whether the authors encountered any trouble from vibration. In some calculations that the writer has made in connection with the design of a fatigue-testing machine, he found that any eccentricity of the specimen, when the specimen is deflected by weights, sets up serious stresses due to the acceleration effects at high speed.

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[12] Reynolds and Smith: *Op. cit.*

[13] Eden, Rose and Cunningham: *Op. cit.*

[14] J. H. Smith and G. A. Wedgwood: Stress-strain Loops for Steel in the Cyclic State. *Jnl.* Iron and Steel Inst. (No. I, 1915) **91**, 365.

[15] William Mason: Alternating Stress Experiments. *Proc.* Inst. of Mech. Engrs. (Jan.–May, 1917) 121.

Use of Manganese Alloys in Open-hearth Practice

Discussion of the paper of S. L. Hoyt, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 277.

Samuel L. Hoyt.—The question of adding the ferromanganese to the ladle or to the furnace involves both theoretical and practical questions and its discussion might very easily occupy the rest of the day. One of the points to be kept in mind is the desirability of obtaining uniform steel. If ferromanganese is added to the ladle, it is necessary first to melt the manganese and then to distribute uniformly throughout the heat. The only heat available for this purpose is that of the molten steel itself. No doubt sufficient heat is present, but in our desire to pour the steel as quickly as possible there is hardly sufficient time allowed, many times, for the proper distribution of the manganese. In other words, this is an operation which takes a certain amount of time and any undue shortening of the time allowed must affect the quality and uniformity of the steel.

Again, this particular method does not lead to as efficient a use of the manganese as might be desired; a contention which is based on theoretical grounds. In concentrated solution, manganese will completely reduce all the ferrous oxide, the presence of which I hypothecate and produce, as the reaction product, manganese oxide. In dilute solution, the manganese only partly reduces the iron oxide, but the manganese oxide which does form dissolves the iron oxide in simple solution. The dissolution of ferrous oxide in the manganese oxide will result in a more economical utilization of the manganese and an equal purification of the heat. This whole point, at present, has not been definitely proved and its answer will involve very difficult research work.

On the other hand, if the manganese is added to the furnace, the heat of the furnace is used to melt the alloy and there is plenty of time during tapping for the manganese to be very uniformly distributed throughout the steel. By distributing the alloy throughout the charge we can secure a better utilization of the manganese than is possible if the addition is made to the ladle. Certain other points, such as the recovery, have been dealt with at greater length in the paper.

The practice of adding manganese in the molten condition to the ladle commends itself for two reasons, considered in the light of the present discussion. It is possible to pour the molten ferromanganese or molten spiegel mixture in such a manner that it unites with the steel stream so that at no time is there a considerable excess of manganese. This insures a proper utilization of the manganese. Furthermore, the

manganese, at the same time, is distributed uniformly throughout the heat.

THE CHAIRMAN (HENRY M. HOWE, Bedford Hills, N. Y.).—We must admit that at first sight the addition of ferromanganese in the ladle seems to be an economy: Less of it is required and there is less opportunity for oxidation and loss. But if you are making cannon or other superior steel and want high quality there can be no doubt that the addition should be made in the furnace. One very important point is that the steel in the ladle should not be completely molten. This is shown by the fact that all good practice requires that steel of any good quality should leave a considerable skull in the ladle, and, of course, the metal which forms this skull is not only below the liquidus but below the solidus. This almost necessarily implies, in view of the pretty wide gap between the solidus and the liquidus, that the steel as a whole is below its liquidus. This in turn implies that it is not a true liquid, but an emulsion of particles of solid steel suspended in a mass of molten steel.

If under these conditions you throw cold solid metal into the ladle it is probable, but not very easy to show, that the emulsion will immediately solidify around the cold ferromanganese and form a lump, perhaps the size of your head, of ferromanganese on the inside and solid steel on the outside. Then before it is possible to diffuse and distribute that manganese it is necessary to melt off the solid steel to get at the manganese. That I think is the great consideration. If you are going in simply for economy and to make steel as cheaply as possible, and if the cheapest steel is as good as the public needs, by all means add the ferromanganese in the ladle; but if you want to make really good steel add the ferromanganese in the furnace.

FRANK N. SPELLER,* Pittsburgh, Pa.—The addition of manganese to the open-hearth bath does not always give the most beneficial results in the finished product, depending on what operations the steel is put through in fabrication. To get the cleanest steel, no doubt additions to the furnace give the best results due to the more thorough mixture and more complete removal of byproducts of deoxidation; but on the other hand this tends to produce a "dry" steel, which gives rise to a more rapid crystalline growth and tendency to overheated structure in subsequent heating. This is what we find in making welds with steel too highly finished either by this or other means. It is unsafe, therefore, to accept the statement of previous speakers without reservations; viz., that to get the best results the manganese additions should not be made in the ladle.

HENRY TRAPHAGEN,† Toledo, Ohio.—Prof. Hoyt has demonstrated that a satisfactory manganese content can be obtained in open-hearth

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† Met. and Chem., Toledo Steel Castings Co.

steel by the use of these low-grade manganese silicon alloys. In fact, the claim seems to be established that the manganese return from this material is higher than usual. Does this mean that the higher manganese return is due to better than usual melting conditions, or does it mean that the manganese in these alloys is below par in deoxidizing power? I rather incline toward the latter view, for I have invariably found, in practice, that the lower grades of manganese alloys were deficient in this respect. They usually show a high yield but fail to properly kill the bath.

The heats, under Prof. Hoyt's management, may have been made under ideal conditions and the amount of oxidation kept at a minimum. If this were so, then 80 per cent. ferromanganese should have shown a greater than usual yield, if it had been used. But if these low-grade alloys consistently show a higher return than the standard ferromanganese, then look to your steel. Be certain that it is up to par, not in one instance, but throughout a long series of test heats, before accepting low-grade ferromanganese as the solution of manganese conservation.

There is no doubt that this manganese question will be solved. But when it is solved, we shall certainly change our ideas regarding the amount of manganese necessary in good steel, for we will find that the solution lies in good raw materials carefully melted, and that true conservation will result from the knowledge that very much less ferromanganese per heat is required. But this will never happen until quality becomes our national watchword, and the present-day "pay by the ton, get the stuff out" policy is no more.

S. L. Hoyt.—I would like to ask for a little further consideration of that last point. Would you mind stating the reason why the high of percentage of manganese should give better steel?

Henry Traphagen.—I base my remarks on the statement that the recovery of manganese from this low-grade material is so high. It appears to me that if the recovery is very high the manganese has not been doing its work. Personally, I would rather have the manganese lost under certain conditions than have it go into the steel. By that I do not mean that I would rather see the manganese thrown into the slag and carried out into the dump, but I would like to see the manganese utilized in cleansing and quieting the steel, rather than see it passed into the metal along with a mass of undecomposed oxides.

C. L. Kinney, Jr.,* South Chicago, Ill. (written discussion†).—It is obvious that the subject matter of Mr. Hoyt's comprehensive paper can only be briefly discussed upon one basis, namely, quality of product; and this basis is selected in the conviction that the steel industry will be confronted, year by year, with an ever-increasing need of meeting more diffi-

* Superintendent, No. 1 Open Hearth, South Works, Illinois Steel Co.

† Received, Feb. 15, 1919.

cult physical specifications. It follows, then, that no procedure should be considered which in any manner handicaps the producer in meeting these inevitable demands. Conversely, any method that will, in a simple economical manner, produce improvements in quality should be given careful consideration. Further, no method or process to which is attached even a suspicion of sacrifice of quality in the name of production, utilization, or conservation should be considered in any light other than that of commercial retrogression.

I believe it is generally recognized among open-hearth operators that there is only one place to attain quality, and that is in the furnace. True, the steel can be affected by improper pit operation and by careless heating and rolling; but in the main it seems the ever-increasing duty of the steel producer to send to the finishing mills a product that can successfully withstand the stresses imposed upon it by modern mill practice.

It now becomes a question of method of attaining this degree of quality by practices applicable to plants producing large tonnages of basic open-hearth steel. Preëminent among all expedients stands the necessity for thorough deoxidation, and the correlated fact that its products must be given opportunity to escape from the steel. Can one logically assume that these demands are met when a bath of steel, low in residual manganese and covered by a basic slag carrying the general percentage of oxides, is deoxidized by the almost archaic method of hurriedly adding a few hundred pounds of deoxidizer in the ladle and inevitably pouring the steel almost immediately? I am sure that the answer is "No." It therefore follows that deoxidation should not be the grand finale of the process. Rather, it must be an integral part, functioning continuously from the period when the bath is melted and slag formation completed, up to the time of tapping, and at this time such further additions may be made as are indicated by the chemical composition sought. Under these conditions there is apparently but one metal that will function properly and economically, and that is manganese.

Assuming the preceding hypotheses to be sound, the problem becomes: "in what form can this manganese, derived from domestic ores, be most economically and efficiently introduced into the bath?" Certainly not in the form of spiegel or any other manganese-silicon alloy, since the use of either in this manner implies additional melting costs and, further, the silicon of the manganese-silicon alloy used in the basic bath becomes an added burden to a process already overloaded with this element. "By the use of these ores direct in the open-hearth furnace?" Perhaps, although here one is also limited by the silica content, which, if excessive, will unduly increase slag volumes and consequently be followed by higher iron and manganese losses. Apparently the alternative lies only in the

use of these ores by the blast furnaces, and a production therefrom of irons carrying a high percentage of manganese (2.50 to 3.00) accompanied by silicons of 0.50 to 0.75 per cent. and a maximum phosphorus of 0.400 per cent. This latter maximum is a purely arbitrary assumption, since no opportunity has presented itself to the writer for observations of the characteristics of this element above 0.350 per cent. It is apparent that this plan of operation must show manganese recoveries commercially comparable with present practice, and commensurate with the necessity or desirability of utilizing these ores. A comparison of this nature must not be confined to the pounds of manganese per ton of ingots produced in in the open hearth, but must also reflect the enhanced profit to the plant as a whole, which undoubtedly will come from lower rejections and decreased chipping costs, to which must be added that intangible important asset, good will, which comes only from a satisfied clientele of customers.

Exactly what may be expected in the basic open-hearth plants operating with an iron of this nature is difficult to state positively without the accumulation of a large amount of quantitative data. However, experience at one plant working a 1.90 per cent. manganese iron has indicated fairly economical manganese recoveries, combined with very marked decreases in rejections and sulfur content of steel. It is pertinent to add at this point that 95 per cent. of all heats investigated for residual manganese carried a 5 per cent. initial ore charge, the remaining 5 per cent. ranging from 9 to 12 per cent. ore; that neither minimum nor maximum residuals appear in the high-percentage ore column; and that one 12 per cent. ore heat shows a constant residual of 0.31 per cent., which is four points above the average of 0.27 per cent. From this, it seems fair to assume that, with a certain degree of manipulative care, it is not impossible to obtain reasonably fair recoveries of metallic oxides from primary slags before wasting them from furnaces.

Inspection of data derived from twenty-five heats made at different periods, without in any great degree departing from standard practice, reveals the following facts: (1) That residual manganese at 0.30 per cent. predominates throughout a period extending from complete melt to tap. (2) That 0.35 per cent. has been attained in three cases, and in only one has it fallen to 0.19 per cent., with an average of 0.27 per cent. (3) That generally with FeO and MnO in the slag, approximating 15 and 12 per cent. respectively, the average residuals prevailed, provided the CaO content did not fall below 44 or 45 per cent. (4) That the high residuals were almost invariably the accompaniment of a CaO content of 47 to 50 per cent., with no sharply marked increase of the MnO, but did apparently bear some indirect relation to a proper degree of slag fluidity. (5) That these residuals persisted at carbons as low as 0.04 per cent. (6) That there was a very marked decrease in the sulfur content of the steel and also in the finishing-mill rejections.

These heats were made under conditions far from ideal for the most efficient manganese recovery, for, due to siliceous fluxes and refractories, plus high-silicon iron (1.25 per cent.), slag volumes were in excess of what the best practice along these lines demands; and due to a low grade of gas coal, temperature control was practically absent.

From the viewpoint of an exact scientific investigation, the data, on which is based this method of utilizing these low-grade domestic ores, may appear somewhat fragmentary, yet the conclusions drawn are substantiated by results attained by many others who have worked on a large scale along identical lines. So I feel little or no hesitancy in saying that given a high-manganese iron (of previously outlined composition) combined with the lowest possible extraneous silica from fluxes and refractories and a fuller appreciation on the part of the open-hearth personnel of the importance of slag manipulation and control, residual manganese may be driven to and held at 0.40 per cent., that the additions of high-percentage manganese alloys from this point on will be mainly a function of chemical specifications, plus the necessity of making up some small volatilization losses that occur when tapping, and that these additions need be only in such amounts that there will be found not only a material economy in manganese in the high percentage alloys derived from foreign ores, but a reasonable recovery from the domestic ores and the certainty of a more perfect final product.

J. R. CAIN,* Washington, D. C. (written discussion†).—This paper by Prof. Hoyt is a contribution to a field of investigation that has been somewhat neglected; namely, that important stage of steel manufacture known as deoxidation. Undoubtedly the more extended paper he has promised will throw much light on the particular deoxidation practices he has studied at several works and will make accessible much valuable data that has been unavailable.

His paper deals with two particular forms of manganese for deoxidation and two combinations of manganese and silicon for the same purpose and his work shows how, even with the use of comparatively few deoxidizing substances, or combinations, many procedures can be developed. The deoxidizing metals known to be useful for this purpose in the steel industry are: silicon, aluminum, manganese, titanium, and, to some extent, magnesium and vanadium. If these are combined two at a time, a new set of deoxidizers is available; if ternary or quaternary alloys are made, other sets with new properties are obtained. If such deoxidizers are applied with some of the variations in practice frequently used (such as in the quantity used, premelting of the deoxidizer, addition in the ladle or in the furnace or both, treatment in stages using a different kind of deoxidizer at each stage, etc.) it can be seen that the steel maker

* U. S. Bureau of Standards.

† Received Feb. 18, 1919.

has available a great number of deoxidation processes, many of which have never been tried. Moreover, there is a strong probability that manganese, silicon, aluminum, titanium, magnesium, and vanadium are not the only elements available for deoxidation. Some yet untried may be even better for the purpose. Quite likely, too, valuable properties can be imparted to the steel by new variations in deoxidation practice.

The war has emphasized our military need for a systematic study of deoxidation to save manganese, of which the country lacks a sufficient amount within itself for the steel industry. Any interruption during war to importation of manganese ore would be fatal if processes were not at hand for using less manganese, lower percentage ferro, or substitutes. Work along these lines was undertaken during the war by the Bureau of Mines, Bureau of Standards, and National Research Council, in coöperation with steel companies, and it is hoped that this work may be continued, particularly on the broader lines of a scientific study of deoxidation and of new deoxidizers.

Viewing the subject historically, it is evident that the adoption of the deoxidizing agents at present in use was the result of practice developed more or less without scientific knowledge of the mode of action of the deoxidizer. Even now the exact chemical changes affected by the deoxidizer are not known. In fact, the very name "deoxidizer" indicates lack of exact knowledge. Actually, as will be shown by some papers soon to be published by the Bureau of Standards, the deoxidizer exerts but little influence on the oxygen content of a steel—at least in so far as this is determined by some of the frequently used methods. Part of the trouble lies in these methods, as will also be shown by future Bureau papers, but the important point is that the deoxidizing alloy is really added to remove the spongy structure of the metal due to gases. The exact nature of the gases and how they are affected by the deoxidizer has never been satisfactorily determined in a thorough and convincing manner, although numerous workers have thrown much light on various phases of the subject.

The Bureau of Standards is now attempting to develop methods for determining the gases in steel that are affected by the deoxidizer. These methods will then be applied to the analysis of steels in various stages of their manufacture, so that eventually some idea may be gained as to the relative efficiency of different commercial methods of deoxidation in accomplishing what they are intended to do; namely, removing or eliminating the effect of gaseous impurities in steel. Other work is under way with the idea of trying new deoxidizers and deoxidation methods on small heats of steel made under experimental conditions. The progress of the deoxidation will be followed by gas analysis of the metal, and the physical properties of the steels will be fully determined after forging, rolling, and heat-treating as commercially practised.

The foundation for intelligent coöperation in this work between various governmental agencies has been laid during the war, and it is hoped that this coöperation may continue along with an increasing degree of interest on the part of steel manufacturers, who will be aided in their work by every step in the investigations.

Certain Ore Deposits of the Southwest

Discussion of the paper of W. TOVOTE, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 142, October, 1918, p. 1599.

W. G. MITCHELL,* New York, N. Y.—I quite agree with Mr. Wilson[1] in the statement that the Bonanza copper orebodies of the Jerome District are definitely pre-Cambrian. You might go much further than that. It is an interesting fact and, I think, well substantiated that the chalcocite enrichment is pre-Cambrian, and in that particular the deposits are unique, so far as I know, among copper-ore deposits. It is certainly true, under my scheme of classification, at least, and I think it has been supported by the work of Mr. Reber of the United Verde Extension, that chalcocitization was entirely accomplished prior to the laying down of the Cambrian sediments. The statement of Mr. Wilson that no Yavapai schist, as defined by Jagger and Palache, has been found in the Jerome District and that the schist in Jerome is composed entirely of ancient intrusive and extrusive volcanic rocks and bedded tuffs is one with which I am not entirely in accord. I believe that it is true that the schists at Jerome are largely composed of bedded volcanic material, I am also certain that there is a considerable proportion of plastic material in those schists. I have seen a good many slides, and it is quite common to find quartzites and limestones in the schists. At a short distance from Jerome, at the Arizona Binghamton, there are limestone strata in the schists several feet in thickness, and unmistakably a part of the original sediments as laid down.

Another statement of Mr. Wilson is supported by my own observations. In the United Verde mine included fragments of sulfide ore are found in later anthracite dikes, which cut the orebodies but do not invade the chalcocite sediments. This is not only true, but those fragments of sulfide ore that are of small size, from the size of a walnut to fragments 2 and 3 ft. in diameter, are of the original unenriched pyritic material. I have never found high-grade ore, either chalcopyrite or chalcocite, in any of those dikes.

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*Mining Engineer, R. Martens & Co. [1] *Bull.* 146 (February, 1919) 445.

A Study of Shoveling as Applied to Mining

Discussion of the paper of G. T. HARLEY, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 571.

B. F. TILLSON,* Franklin, N. J.—A preliminary study of this paper did not, in my case, succeed in checking with the shovel dimensions of one of the large shovel manufacturers. I therefore raise a question as to there being some difference in standards used by different manufacturers in regard to the dimensions of the shovels for similar sizes and styles, so it may be rather confusing to some of us when we attempt to use the table in this paper and classify the capacity of the shovels as given here with some that are on the market.

Fine Crushing in Ball-mills

Discussion of the paper of E. W. DAVIS, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 111.

A. L. BLOMFIELD,† Colorado Springs, Colo. (written discussion‡).—I congratulate the author on bringing out a paper of real service to the profession. His contention of uniform size in balls is borne out by my own experience; in coarse crushing at the Golden Cycle in 6 by 6-ft. (1.8 by 1.8-m.) ball-mills we unquestionably gain by screening out the small balls once or twice a month. The point of gaging the ball size to be used by the uniformity of screen sizing is of particular interest.

The necessity of sufficient return feed from classifier to the ball-mill is sound and clearly shown. In connection with this, I wish two further points had been gone into as thoroughly: (1) The effect of the quality of classification. In general, it is true that the smaller the per cent. of undersize in the feed the more effective is the mill's work. This is true on a bucking board, in tube-mills, ball-mills, and grinding pans. Given the possibility of returning a full-feed load to any mill, it has been my experience that the effective work in the grinder is almost proportional to the quality of the return feed. (2) Again speaking generally, the shorter the tube-mill the greater is the quantity of return feed necessary to keep it loaded. The classification thus keeps the oversize in the mill more free from finished product and thus the crushing more efficient. It is very easy to overload any long mill with too much return

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‡ Received Feb. 19, 1919.

feed. The author's tests were made on an 8-ft. by 22-in. Hardinge. This type is capable of handling very large return feeds. I would like to hear Mr. Davis' views on the best length of mill, given the diameter.

Dealing with feeds to fine grinders: At the mill of the Great Fingall Cons. M. Co., in 1906, we found that the 5-ft. grinding pan gave the greatest tonnage in closed circuit, grinding a feed − 8+20 mesh to − 20 mesh when the feed was slightly over twice the effective work done, and that the effective work was almost directly proportional to the efficiency of classification.

I note the large number of classifiers in his flow sheet and agree that it is clearly demonstrated that sufficient classifier capacity should be installed, as they cost very little to run. Two 6-ft. classifiers to the ball-mill could probably be replaced by one 12-ft. quadruplex machine, though possibly the only gain would be a saving in first cost.

Problems Involved in the Concentration and Utilization of Domestic Low-grade Manganese Ore

Dicussion of the paper of E. NEWTON, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 379.

C. W. GOODALE,* Butte, Mont.—I notice Mr. Newton refers very briefly to the carbonate ores of manganese, rhodochrosite, but he does not go into any special description of the treatment of that material. In some of the veins in Butte, Mont., there is a large amount of rhodochrosite, and a large tonnage of that material has been shipped to the East for making ferromanganese. At the works of the Anaconda company at Great Falls they treated several thousand tons of this manganese ore, running about 37 to 38 per cent. manganese, in electric furnaces, giving a product of about 78 per cent. of manganese. But just at that time the demand for ferromanganese from the West was discontinued and the material, about 1000 tons of 78 per cent. manganese, is on hand at the works at Great Falls. With the higher-grade manganese ore, running, we will say, 37 or 38 per cent., there are large bodies of ore perhaps 20 or 25 per cent., but containing too much silica to be valuable in their present condition. Some efforts have been made for water concentration of that material, but owing to there being only a difference of about 1 in the specific gravity of the quartz gangue and the manganese mineral, water concentration has offered some difficulties, I have been told, however, that some very satisfactory experiments have been made with magnetic concentration of this material. I think it is a new idea that this manganese ore can be treated successfully by magnetic concentration.

* Manager, B. & M. Dept., Anaconda Copper Mining Co.

KIRBY THOMAS, New York, N. Y.—I want to point out the possibilities in the business of manganese mining which have been made clear by the war. Before the war the manganese production in this country was from 3000 to 5000 tons, practically insignificant; although it had been larger some years before. However, under the stimulus of the war, we have reached a production of about 300,000 tons of manganese ore and at even the pre-war prices that represents a sum that is important even in our vast mineral production. With the termination of the war and the withdrawal of the stimulus of high prices through government encouragement, the manganese mining industry is apparently about to collapse and relapse into its former insignificant position. The war has shown us that there are possibilities in manganese mining in the United States. If the production of 3000 tons annually could be increased to 300,000 tons in 3 years, certainly there is the raw material, the base of an important industry, existing in this country. It must be admitted that it exists mostly under unfavorable conditions, as compared to the competing deposits of Brazil, India, and Russia. The raw material is here, and the engineering talent and the mining industry of this country should display the ability and the courage to tackle that problem. Cannot the engineers turn their special technical skill to realizing this national resource, notwithstanding the relatively unfavorable conditions under which it exists? It looks as if this whole business of manganese mining is likely to lapse until we have another war, or until there is a stimulus of protective tariff, etc., which shall throw us back on our own resources as regards manganese. The problem resolved itself not into one of mining but into a question of metallurgy, and this paper by Mr. Newton touches upon the metallurgical points, but very generally; it does not give enough definite results of what has been accomplished or what may be accomplished.

In the South the treatment of manganese ores was entirely crude, untechnical, unpractical, up to the last 2 or 3 years, but Mr. Newton and others connected with the Bureau of Mines have worked out a number of very important things in regard to the treatment of those southern manganese ores. They have studied and diagnosed the old log washer, which was hardly supposed to be a metallurgical instrument, and have found that the washers should be of a certain length and have a certain revolution and particular shaped blades. All that work is important. There has also been work done with regard to the chemical separation of manganese out of the silicate and carbonate ores. This is a problem that should be followed up.

In Maine there is a deposit of silicate ore, a whole mountain of it, that runs 22 per cent. manganese. It is located favorably and if someone can work out a process of getting the manganese in the form of steel or chemical manganese, it will add a large value to the country's mineral production. The same is true of the rhodochrosite ores of the West and the

high-silica ores of Arizona and the Southwest. I urge that further consideration be given to this subject, with a view of continuing the investigation of processes of realizing the potential wealth that lies in the manganese deposits of this country. We are tackling a difficult problem and one in which the competition of the foreign supplies is against us, but it is a patriotic and selfish duty to try to develop our own industry and through public or private stimulation, the work should be continued.

Anthracite Mining Costs

Discussion of the paper of R. V. Norris, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 249.

Edward W. Parker,* Philadelphia, Pa. (written discussion†).—The two papers on coal-mine costs and price fixing that Mr. Norris has contributed to the *Transactions* possess as much general interest and are of as much value to the coal-mining industry as any papers that have been presented in recent years. Until recently one of the troubles with the coal business, and especially the bituminous branch of it, has been that because of the lack of a uniform system of cost accounting (many operators, I regret to say, not having had any system at all), the industry as a whole may be said not to have known where it was at. The system adopted by the Federal Trade Commission may not be absolutely perfect but it has accomplished something in that it has compelled a uniform method of reporting and tabulating costs giving results of these compilations which are comparable.

The Institute and the coal-mining industry owe a vote of thanks to, and of confidence in, Mr. Norris and his two associates on the Engineers Committee of the Fuel Administration, Messrs. Garnsey and Allport, for the great work they have done in interpreting the results compiled by the Federal Trade Commission, not to speak of the personal sacrifices made by them in giving their services to the government.

Those who have read Mr. Norris' paper will probably join me in wishing he had brought out a little more fully the real meaning of the charts so far as they indicate the difference between the cost of producing a ton of anthracite and the price the operators receive for their product. Mr. Norris could have done this more satisfactorily than anyone else. It seems to me that particular attention should be drawn to the fact that, according to these charts, and the tables accompanying them, not less than 25 per cent. of the total output of anthracite, whether "company" or "individual," during the period covered by Mr. Norris' paper,

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* Director, Anthracite Bureau of Information.

† Received Feb. 24, 1919.

was produced at an actual loss on the operating costs alone; for, as I understand it, these figures do not include certain administrative salaries, interest on bonds or borrowed money, losses from bad debts, income or other Federal taxes, and some other overhead charges. According to Chart 1, which gives the production and costs of all the companies reporting for a period of 6 months, about 10 per cent. of the output was mined at a loss of 40 c. a ton or over. A study of Charts 1, 2, and 3 shows somewhat of a paradox. Charts 2 and 3 show separately the operating costs of the "companies" and "individuals." In each case 20 per cent. of the output was produced either at no profit or at a loss, whereas when we consider the total of the two, as shown on Chart 1, 25 per cent. of the total output was sold at or below cost.

The explanation, as I see it (and Mr. Norris will correct me if I am wrong), lies in the fact that the individual companies, on the government price-fixing arrangement were allowed a differential of 75 c. per ton on their output of prepared sizes above that permitted to the "company" operators. The average realization for the "company" coal was $4.29, and the average realization on the "individual" output was $4.82. Five million tons of "company" coal were mined at a cost in excess of $4.29, the average realization for that coal, while 1,590,000 tons of "individual" coal were mined at a cost above the average realization of $4.82. The fact that the larger portion of the coal mined at a loss was "company" coal accounts for the apparent inconsistency.

The United States Fuel Administrator had before him the originals of these charts and knew exactly what the situation was when the prices were fixed. As Mr. Norris has stated, while the bituminous prices were fixed upon the basis of cost and reasonable profits were allowed to the operators, the prices for anthracite were fixed apparently without any relation to the cost. When the advance in wages was granted by the supplemental agreement of November, 1917,[1] to take effect the first of the following month, it was estimated that the additional cost would amount to about 45 c. a ton. The Fuel Administration, however, seemed to be impressed with the idea that in preparing this estimate the anthracite operators had included a sufficient factor of safety to cover any possible chances, so instead of permitting an advance of 45 c. per ton to cover the estimated increase in cost, it permitted only an advance of 35 c. That the operators were out in their estimates by approximately 100 per cent. is shown by the fact that the actual results of the wage advance in November, 1917, was an average increase in cost of 76.4 c. per ton, or something more than twice the advance in price permitted by the Administration.

When, in November, 1918, it was found necessary again to increase

[1] Supplemental to the agreement of April, 1916.

the wages of mine workers, these facts were placed before the Fuel Administration and they were verified by the Administration's own Committee of Engineers and based upon the reports made to the Federal Trade Commission. As I have stated, the Fuel Administrator had before him these charts which are now presented by Mr. Norris in his paper, so that Mr. Garfield knew at that time that the operating cost of one-fourth of the anthracite output exceeded the prices obtained for it. He knew, moreover, that the average margin on the entire output of anthracite was not a safe one and that it did not represent what was specifically called for in the Act of Congress providing for the control of prices by the Fuel Administration, namely, that the prices fixed by the government should guarantee a fair and reasonable profit. The Fuel Administration, on the first of February, when it practically laid down the scepter of office, confessed the injustice of its behavior toward the anthracite industry and admitted that the prices of anthracite should have been at least 50 c. more per ton than the Administration had allowed. The significant part of the statement which accompanies the order freeing anthracite from further governmental restrictions is as follows:

"For the purpose of arriving at a fair increase in price to cover the increase in wages recommended by the War Labor Board last October, an examination was made to determine the costs of the various anthracite producing companies. The result of this examination showed that the general increases in the price of materials and labor have raised the cost of mining anthracite to such an extent that many of the companies were not receiving a fair return and that some producers of necessary coal were actually sustaining a loss on the sale of coal at government prices, in spite of the two increases allowed on account of the advances to labor.

"The above statement is made * * * * out of fairness to those companies who have patriotically kept up their production to war needs, even at a cost which resulted in many instances in a loss, not only by individuals, but also by some of the railroad companies * * * *.

"Had the Fuel Administration's active control over maximum prices on anthracite coal been continued, the cost examination above referred to shows that it would have been necessary, on the basis of the present wage scale, to raise these maximum prices possibly as much as 50 c. a ton * * * * to prevent financial embarrassment and perhaps the closing of companies producing a substantial per cent. of the necessary anthracite output."

It is to be noted that in the opening sentence of this statement Dr. Garfield states that examination was made for the purpose of "arriving at a fair increase in price" and then in the final paragraph admits that a fair increase would have been at least 50 c. more than was permitted.

In the course of recent investigations into the anthracite industry by

the Sub-Committee on Manufactures of the United States Senate, it was testified by the chief engineer of the oldest anthracite mining company in existence—and one that is now producing from 4,000,000 to 5,000,000 tons per year—that the margin between the selling price at the mine and the cost of production for the entire year of 1918 was 6.89 c. per ton, a little less than 7 c. Out of this 7 c., it should be remembered, must be paid the administrative salaries, interest on bonds, Federal taxes, and dividends.

That conditions were not improving toward the close of the calendar year, but on the other hand were going from bad to worse, was shown by the fact that this margin for November was 5.6 c., while in December there was a loss of 2 c. per ton. I understand the January statement shows even worse "in the red."

R. V. NORRIS.—I wish to say, in regard to Mr. Parker's discussion, that the prices were not fixed by the Fuel Administrator. He only allowed an addition for an increase in December; the prices were fixed by the President and, except in the case of pea coal, have only been adjusted for labor changes. The adjustments were based on averages and not on the labor increase of the higher cost companies. Chart 5 shows the increase for each company, and you will note a varying increase from a relatively small increase for the low-cost companies to a considerable increase, amounting to over a dollar a ton for all sizes, for the high-cost conpanies. This is perfectly natural, as the labor increase was not a percentage but a flat one, except in the case of the miners, and necessarily the high-cost companies had a higher labor cost and therefore a larger actual cash increase and a larger increase per ton.

S. D. WARRINER,* Philadelphia, Pa.—The anthracite industry is much indebted to Mr. Norris and the engineers of the U. S. Fuel Administration for the careful study they have made of the complicated subject of anthracite cost and realization. It is unfortunate, however, for the industry at present, and ultimately for those who desire, and require, an abundant supply of anthracite, that the Fuel Administration did not apply to anthracite the principles of price fixing recommended by its engineers and actually adopted in the case of bituminous coal. The application of these principles to anthracite would have stimulated productivity when greater production was a war necessity, and would have left the industry with its natural markets unimpaired and in better financial condition to meet the difficulties of the readjustment period. The statement of the Fuel Administrator on lifting restrictions is an acknowledgment that the policy of price fixing followed by the Administration with respect to anthracite was not based upon the costs as determined by his engineers, and that readjustments are necessary to prevent financial embarrassment and to avoid an ultimate shortage in supply with its consequent increased cost to the consumer.

* President, Lehigh Coal & Navigation Co.

The charts presented by Mr. Norris are illuminating but do not fully represent the present situation, which had arisen from the Fuel Administration lifting its restrictions and leaving the results of its price fixing to be paid for, not by the government as in the case of wheat, but by the industry upon which the regulation was imposed. These charts show costs that do not include the cost of marketing (at least 10 c. per ton) or interest on investment, which at 5 per cent. on the average capitalization found by Mr. Norris would be 40 c. per ton. We must, therefore, deduct from his realization 50 c. per ton before the operator realizes any recompense for the risk of his business as compared with an investment in a well secured bond.

The pressing demand during the war for anthracite throughout New England and the Atlantic seaboard, caused by the increased population of war workers and the activities of war industries, as well as the requirements of the government itself, necessitated a policy of zoning anthracite out of certain States and Territories and prohibiting its use for many purposes for which it was normally used.

Following the signing of the armistice, the sudden let-down in activity, combined with the effects of a warm winter, speedily resulted in a surplus of coal which has made it impossible for the individual operator to secure the maximum price allowed by the Fuel Administration and has naturally brought all maximum prices down to company prices. Even at these prices coal cannot now be moved in volume for the reason that the market in the territory apportioned to the industry has been fully supplied, and the market from which it has been excluded has been supplied with adequate fuel substitutes for its normal requirements.

Chart 2 shows company realization allowed on the adjusted standard $4.29, or if we deduct 50 c. for selling and interest, $3.79. As against these figures the average cost was found to be $3.91, consequently of the total fresh-mined tonnage at least 35 per cent. shows an actual operating oss, and 60 per cent. a financial loss on a 5 per cent. basis for capital.

These figures (Chart 2) more nearly reflect the present relation between cost and realization than the figures in Chart 5, which show the increase in cost and realization due to the adjustment of Nov. 1, 1918. Chart 5 shows the combined cost of fresh-mined and bank coal, but as the market for bank coal largely ceased with the war, fresh-mined coal alone should now be considered. Furthermore, the realization shown on Chart 5 is the average of company and individual prices; and as only the company price is now obtainable the prices shown on Chart 2 should be taken as the basis to which the adjustment of Nov. 1, 1918, should be added.

As the price allowance of November merely covered the average increase in cost due to wages, each ton of coal mined above the average cost was not fully compensated by the increased price allowed. Further-

more, as the consumption of steam sizes (averaging 35 per cent. of the entire output) has shrunk with the slackening of industry, there has been a reduction in the prices of these sizes below the maximum heretofore obtained, thus reducing further the average realization. The real situation in the anthracite industry at the date of the lifting of the Fuel Administrator's price restrictions was very much worse than has been depicted, and it is probable that more than 60 per cent. of the output is now being mined at a loss.

The work of the engineers of the Fuel Administration is of great technical value in its pioneer study of the complicated subject of relative cost and realization, and, it is hoped, may go far to correct the popular misapprehension of great profits derived from the industry. From an economic standpoint, the price regulations actually enforced by the Fuel Administration are of interest as demonstrating the fact that any interference with economic laws is expensive exactly in proportion to the detail with which the interference is carried out. In abnormal times regulation is necessary, but it should be broadly constructive and not restrictive, and of such nature that when the necessity for such regulation no longer exists the laws of supply and demand may again assert themselves, without financial embarrassment to the industry of unnecessary expense to the consumer. The regulations of anthracite prices represented an extreme case of price fixing. The Fuel Administration fixed two prices for the same commodity, which in itself was rather penalizing to the producer than beneficial to the consumer, as local retail regulations became difficult. Neither price was based on cost, as both company and individual mines were in both high-cost and low-cost group. Not only this, but arbitrary prices were fixed on practically each of the nine different sizes, the prices of which under commercial conditions have always relatively fluctuated according to demand. With the reëstablishment of commercial conditions, the prices arbitrarily fixed disappear, the result being financial operating loss to more than 60 per cent. of the industry. The consumer would not be especially interested in this phase of the situation were it not that with the indefinite closing down of high-cost operations, which is now taking place, the capacity of the anthracite mines is reduced below the average annual production normally needed. This will inevitably tend to create a shortage, unless coal can be stored by the companies for future use. Storage, however, is only economically practicable when there is stability of market conditions, otherwise the expense and risk makes it prohibitive. For this reason the trade policy of the industry has been, so far as possible under existing laws, to promote stable conditions by the summer discount in price, thus encouraging the consumer to store a part of his winter supply, the operator storing the remainder. By this method steady operation of the mines was insured and the annual supply required by the market

obtained. For a number of years the anthracite industry would otherwise have been unable to supply the market requirements.

Today the anthracite industry is left by the Fuel Administration under the handicap of inadequate prices, a wage structure still under government control, and a tendency toward declining prices in all commodities, with the problem of recreating the stable commercial condition necessary to the prosperity of the industry as well as to the comfort of those who are dependent on anthracite for fuel.

PAUL STERLING,* Wilkes-Barre, Pa.—There is an impression that the inspection of the coal has been let down during the strenuous times of the last 2 years, but in the company that I represent the inspection department maintained its standard during the entire period of the war and we maintained the same inspection in production that we always had prior to that time.

W. V. DECAMP, Edgewater, N. J.—I realize that the discussion on the paper is entirely along the line of anthracite mining costs and that no effort has been made to state what factors tended to increase the cost of coal, other than increase of supplies and the increased wage, and I would like to ask if Mr. Norris has any data in regard to what possible decrease in efficiency occurred during the period mentioned, especially the efficiency of labor? Also, if 25 per cent. of this coal was produced at a loss, did the companies that produced said coal at a loss make a reasonable profit in pre-war times, when the conditions were different, or were they companies that were beginning operations or increasing operations and working under some other than normal, high-production conditions? In addition, what general changes, if any, were made in the general mining methods, or in general organization methods, to meet the rapidly increasing costs, since that is a question in which the engineer is always interested, whether it is metal mining or coal mining?

R. V. NORRIS.—I will try to answer the three questions. In the first place, there was a notable decrease in efficiency, caused largely by the fact that the younger men went into the National Service, and that their work was necessarily taken up by older and less active men. The decrease was particularly notable in the transportation end of the service, as the older men did not have the snap of the younger men they replaced. There has been a very great decrease, from about 180,000 to about 142,000, in the number of employees in the anthracite region, with about the same actual production, but production was maintained not by increased efficiency, as would seem to be the case, but by more working days and longer hours, which the men in most cases willingly gave.

Second, the high-cost companies are all old, well-established and presumably profitable companies. In the case of the large high-cost com-

* Mechanical Engineer, Lehigh Valley Coal Co.

panies, hey have been paying dividends for many years. The excess cost was caused by their efforts to hold an increased production with a lessened supply of labor and that more poorly trained.

Third, there could be no sweeping changes made during the war; the effort was intense to hold the production. It was almost out of the question to make any serious changes in methods at that time. The production was, of course, largely held by reducing development work, and I look forward to a long siege of extra development work, to put the mines back to where they were at the beginning of the war. I am confident that development work was necessarily very much neglected and that the coal which had been put in sight by previous development work was largely mined to hold the production for war purposes.

EDWIN LUDLOW,* Lansford, Pa.—The question of decreased efficiency of the men working in the coal mines, which has just been raised, I am able to answer, as it is a point that is followed very closely by the Lehigh Coal & Navigation Co., and the tons per man hour is worked out in tabulated form. During the year 1917, the tonnage per man-hour was 0.026 and for the year 1918 it was only 0.022. The production for the years 1917 and 1918 was slightly in excess of 5,000,000 tons, with more working days in 1918 than in 1917. If the same production per man-hour had been maintained in 1918 as in 1917 the tonnage would have been 860,000 tons greater.

This loss in efficiency cannot be attributed entirely to the high wages and indifference of the men to keeping up a full production, as this was true of only a small proportion; while on the other hand our foremen and their assistants worked to the physical limit of their ability in long hours and without holidays in their endeavor to keep everything in operating condition. Our loss is more attributable to the 910 of our men who went into the service of the U. S. Government, of whom only 336 were drafted, the remainder enlisting. The class of work from which these men were taken was that requiring youth and quickness in order to produce efficient results, and the older men with whom we were obliged to fill their places could not be expected to do as much work as the younger trained force that had gone into the service of the government. There was also difficulty in keeping up the discipline, as the shortage of men made it impossible to replace anyone that we wanted to discharge and our efforts were all concentrated in trying to produce the best results with the material that we had.

In regard to the advances granted by the Fuel Administration in the selling prices of coal as compared to the advances granted in wages: A concrete example of one company may possibly bring this matter more clearly to those who are not interested technically in coal mining. The

* Second Vice-president, Lehigh Coal & Navigation Co

pay roll for the Lehigh Coal & Navigation Co. for the year 1918, on the basis of the wages established by the contract between the miners and the company, which was supposed to remain in effect for 4 years, expiring Apr. 1, 1920, would have amounted to $8,000,000. The war allowances that were granted to cover the increased cost of living and which were approved by the Fuel Administration, who endorsed the agreement between the men and the company, amounted to $3,000,000, and the increased selling price on the prepared sizes of coal, granted by the Fuel Administration, for the year 1918 increased the revenue from the coal sold by $1,500,000. This loss of $1,500,000 was partly made up by the increased prices obtained for the steam coals, but the prices of the steam sizes are dependent on the prices of bituminous coal, and if bituminous coal becomes cheaper, the prices of the steam sizes of anthracite will undoubtedly fall in proportion. No allowance was made by the Fuel Administration for the increased cost of material. This increase for the year 1918 over the year 1917, with the same tonnage produced, amounted to $906,000. The scale of wages as now fixed, including these war allowances, is practically on the basis of the wages paid to the railroad employees by the government.

The cost of living is still high, and it does not appear to be in any way practical or advisable to attempt a reduction of wages at this time. The anthracite companies and the consumers of anthracite are, therefore, faced with the fact that there will have to be an advance made in the selling price of the prepared sizes of anthracite coal in order to enable the companies to come out even. If there should be no advance, it would mean that a large proportion of the higher cost collieries would have to be closed, bringing on a decreased tonnage of anthracite, which would not enable the anthracite companies to produce enough coal next year to meet the demand; and with such a shortage the prices of anthracite would jump, as they have frequently done in the past when there has been a shortage of that kind and no restrictions as to the maximum prices which might be asked.

It would, therefore, appear to be the wisest for both the consumers and the companies that a gradual increase in prices should be made to cover the actual costs as determined by the engineers of the Fuel Administration as being the necessary prices to enable the companies to live, so that they may be able to maintain their tonnage and be prepared to meet the demands of the country for fuel next fall when coal will be needed as it always has been.

Work of National Production Committee, U. S. Fuel Administration

Discussion of the paper of J. B. NEALE, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 439.

ROBERT PEELE,* New York, N. Y.—I should like to ask Mr. Neale how the members of the production committees at the individual mines, who came from the mine workers themselves, were chosen or appointed; also from what classes of employees they usually came?

J. B. NEALE.—In the union fields, they were chosen by a local. In the non-union fields, they were chosen either by the men in mass meeting or by the company officials. The last way was very unsatisfactory because it gave the men an opportunity to say that they were going to be passed upon as to whether they were slackers or not, by men chosen by the company. When they were chosen by the locals or at mass meetings of the workers, the appointments have been very much more satisfactory.

R. D. HALL,† New York, N. Y.—The matter of inefficiency on the part of the operator is one that I think we may well take into account, because there is a very large inefficiency on the part of the coal operator; it has arisen from reasons almost beyond his control and will continue for these same reasons. It is no use arguing a moral responsibility on the part of the operator, when you make efficiency very largely a loss to the operator who puts it in force. If you ask a man working on a day wage to work with more efficiency he says, "Well, I may do it or I may not," it all depends how he feels, but he does not lose anything financially by not working hard. If you ask the man who is working by the ton to put out more tons, he makes a profit by putting out more tons. How is it with the operator? If he gives a man all the cars he needs and all the power he needs, if he runs after his working men and waits on them, he does not get his coal out any cheaper than before. He gives the man a better chance and there is more efficiency, but at the same time he has increased his expenses all along the line. At the end of the year he finds that his profits have been less than if he had had less efficiency. The efficiency is really against him in many ways. Because he gets a larger tonnage, he reduces the overhead to a certain extent; but his tonnage may not be any greater because he may work fewer days. As Mr. Taylor remarked some time ago, supposing he puts in a machine that is very much more effective than any he had before, he has the same scale; the miner gets out more coal, but he himself does not get any benefit out of it because he has a scale fixed, so much per ton.

So long as we have piece work of that kind, it will hardly pay the

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† Associate Editor, *Coal Age*.

operator to go out of his way to help the working man; his interest is not with the working man, as it should be, and it never will be unless he is paid by the day. There is a great deal of efficiency in the transportation system in mines, in the dumping system, in the cleaning of the coal, and in all those various features, because it is on day labor; but when a foreman sees a miner doing nothing and learns that he is waiting for cars, he says, "They will be along in a short while." It does not worry the operator at all that that condition exists. He realizes that if he were to put on more drivers he would have some drivers waiting, and drivers are paid by the day and miners are paid by the ton, so he really feels it is more profitable for him to have fewer drivers and more miners. Not only that, but it has been found that when the miner is given cars whenever he needs them, he is liable to quit the mine early, with the result that in the afternoon things drag along and the work is very inefficiently done on the part of the day-hands; and it is their efficiency in which the operator is interested.

So long as coal mining is conducted largely on the piece-work plan we will find a lack of efficiency on the part of the operator. There is no inducement to the operator for any efficiency that he may exhibit, and to my mind the only hope is that we will some time get a combined system in which the man will be paid partly by the day and partly by his work. When that is done, we will find that the operator will have an interest in reducing the number of men employed in his mine, and the miner will have the advantage, in that the more coal he produces the larger will be his income. But so long as the miner works entirely on the piece-work plan the operator will have no incentive. In fact, he will have an incentive entirely in the other direction, because the more efficient he is, the more he tries to give the miner a fair show, the more he will find his costs will mount up, and he cannot meet those costs under present conditions of competition because these costs do not bring him a return. I think that the whole trouble is the system on which the mines are worked, and that it will never be corrected until we have changed the system.

R. V. NORRIS, Wilkes-Barre, Pa.—I think some of the operators will wish to answer Mr. Hall. I do not agree at all with this proposition that the piece work of the miner tends to inefficiency; as a matter of fact, the piece work of the miner has been the custom in practically all coal-mining operations, for the reason that there is no means of supervising the miner's work and that piece work has been found to be the best method to encourage him and make it to his advantage to work. It is also an unquestioned fact that a very considerable part of the expense is overhead, which is reduced by increased tonnage, and I feel very strongly that the piece work of the miner is the best and most advantageous method for the mining work.

Path of Rupture in Steel Fusion Welds

Discussion of the paper of S. W. MILLER, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 311.

A. M. CANDY,* Pittsburgh, Pa.—I think more stress should be laid upon the question of welding with the carbon electrode, which we ordinarily call graphite arc welding. Mr. Miller's photograph indicated that the original parent metal had been decarburized to a marked degree. It would be interesting to know the carbon content of the parent metal, and whether or not Mr. Miller has made any investigations to determine if the metal is always decarburized or whether in some instances we actually have carbon injected into the weld, which has been the understanding that has been quite prevalent.

There were one or two other points that Mr. Miller brought out concerning which I desire to ask one or two questions: The illustrations that he presented were obtained with what, I suppose, would be termed a real low-carbon steel welding wire, which gives in the deposited metal grains that are more or less symmetrical, whereas the Roebling electrode, which is a mild steel of higher carbon content, apparently gives a columnar structure. I do not know which of these structures is more desirable, but assuming that the structure produced by the really low-carbon steel wire is the more desirable, would it not be true that the very low carbon content would, probably owing to high temperatures that prevail in the arc, result in a greater amount of oxidation and probably result in either carrying into the weld more oxide or producing more oxide on the surface as the operator progresses?

The short arc is an advantage in all cases. Whether Mr. Miller's trouble is oxide or nitride, the short arc helps him out, because the closer the end of the electrode is to the work the less chance there is for either oxygen or nitrogen to get in. And whichever is the cause of the trouble, the short arc keeps it out by lessening the time in which the steel is molten and the amount of air that gets in. It also makes sure that the molten metal will not fall into the crater. Everything is in favor of the short arc.

How can that short arc be obtained? With an ordinary direct-current machine there is nothing to limit a man to a short arc; but every good operator will limit himself to a short arc. There is one direct-current system that necessitates holding a short arc due to the low voltage; other systems provide relays and other moving parts to snuff out the arc when it reaches a certain voltage, but in the case of the machine that

* General Engineer, Westinghouse Elec. & Mfg. Co.

develops low voltage, penetration is lost, for that depends not only on the amount of current but also on the line voltage. The low-voltage machine (35 volts) is not so satisfactory as a higher voltage machine (60 volts) because the operator will experience more difficulty in holding the arc As a result, the arc will be broken more frequently, materially reducing the operator's production and producing a larger percentage of slag inclusion due to the oxidation always occurring on the surface of the crater where the arc breaks. Because of the larger number of arc interruptions, also, the metal in the crater is always noticeably porous. On the whole, therefore, instructing an operator as to the advantages of holding a short arc and giving him a reasonable open-circuit voltage (60 volts) will produce the most satisfactory results because the effect of momentary long arcs cannot be detected in the welding work.

George F. Comstock,* Niagara Falls, N. Y. (written discussion†).—This paper by Mr. Miller is a very interesting study of fusion welds, and his conclusion that films at the grain boundaries cause brittleness in such welds certainly seems well founded by his work, and gives the paper practical value as well as interest. There are a few minor details of the paper that might be criticized, and a few suggestions also that I would like to make. In the first place, nitric acid in ethyl alcohol has been found in our laboratory to work much better in developing grain boundaries than the same acid in absolute alcohol, and it does not roughen the ferrite grains so much.

The author's belief that all patches that darken when boiled in sodium picrate must contain carbon is erroneous, as there is no doubt but that nitride is also darkened by this treatment; and it is hard to see why cementite films should exist in decarburized metal full of oxide spots, as seems to be assumed by the author in some cases. The limitations of the ordinary processes of polishing these metal specimens do not seem to be appreciated by the author, for when one stops to consider that the final polished surface is obtained by eliminating scratches by surface flow of the metal, and that in the preliminary grinding it is rather easy to erode brittle non-metallic inclusions, there should be no surprise if occasionally a very fine crack or brittle film is covered up in polishing so that it is invisible in spots.

I would like to ask Mr. Miller, as a matter of theoretical interest, for his opinion as to why the needles appear only at the surfaces of oxy-acetylene welds, and not in the interior as is the case with electric welds.

I would also like to ask if it would not seem reasonable to suppose that the intercrystalline brittleness and excessively columnar structure noticed in welds containing manganese, vanadium, or aluminum may be due to

* Metallurgical Engineer, Titanium Alloy Mfg. Co.

† Received Feb. 24, 1919.

oxides of these elements which oxidize before iron, depositing in a finely divided state along the grain boundaries? In this connection it seems unfortunate that titanium has not been tried as a means of collecting and removing these finely divided oxides, in view of the general experience with this element in the ordinary processes of steel manufacture.

Welding Mild Steel

Discussion of the paper of H. M. HOBART, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 517.

A. M. CANDY,* Pittsburgh, Pa.—According to the tables on page 532, the deposit obtained with Roebling cold-rolled steel, and Toncan electrodes contained considerably less carbon and manganese than the original electrodes; whereas very little carbon is lost in the case of the hot-rolled steel electrode. When using the hot-rolled steel electrodes, the metal apparently has a tendency, probably due to greater surface tension, to pass through the arc in larger particles than the other electrode materials. This affords greater protection against oxidation, and thereby prevents much loss of carbon. The larger globules tend to increase the arc fluctuations due to greater partial short-circuiting of the arc. Actual oscillographic records show that with the hot-rolled steel electrodes the current peaks were 70 per cent. above normal whereas the peaks for the other electrodes were only about 25 per cent. above normal. Probably due to the larger globules, a greater proportion of slag in the electrode was carried into the weld. Some four or five test pieces made with the hot-rolled steel electrodes were all considerably below the tensile strength of the samples welded with the other electrodes. These facts indicate that an electrode may not be satisfactory even though of approximately the proper chemical composition. For example, the hot-rolled steel and Roebling electrodes are quite similar in chemical analysis.

SPEED OBTAINED IN ARC-WELDING SHIP PLATES

Test No.	Speed, in Feet per Hour	Current Used	
		Amperes	Cycle
1	3.33	170–180	
2	2.86	150–160	
19	1.90	150	60
20	1.48	175	60
21	1.59	105	25
22	0.97	160	25

* General Engineer, Westinghouse Elec. and Mfg. Co.

On page 534, the relative speeds of alternating- and direct-current arc welding are mentioned. By referring to Table 4 on page 560 we find that tests 1 and 2 were made with direct current, that tests 19, 20, 21 and 22 were made with alternating current. The speeds of welding are shown in the accompanying table. Of course these are isolated cases, but it is interesting to see what is obtained from actual tests.

On page 543, Mr. Hobart has brought out the question of suitable current values. This is probably one of the most important and least understood problems in the entire arc-welding category. In fact, it is the problem of proper fusion in arc welding, which can only be secured by the use of the proper current volumes, depending on the characteristics and temperature of the material to be welded, and by the use of the proper diameter of electrodes for the current. A visual inspection of the deposited metal will almost unfailingly indicate when the desired effects are obtained. The method of determination is very ably and clearly pointed out in Mr. Eschholz's[1] paper; namely, judging the penetration metal by the depth of the arc craters, measured from a straight line across the crater top to the bottom of the crater, and an examination of the edge of the deposits for re-entrant angles, to see how much of an angle there is.

Mr. Hobart also made reference to the effect on arc welding of voltage employed. I do not believe that the question of voltage is quite as simple as inferred, unless coated or wrapped metal electrodes or carbon electrodes are used. We will grant that for most open work an experienced conscientious welder can produce results with circuit potentials as high as 250 volts; however, an inexperienced or a careless operator will follow the course of least effort and maintain a long arc, resulting in an unconcentrated porous deposit, which will be poorly fused and does not penetrate into the shank metal. An inexperienced operator certainly ought not to be trusted with such high open-circuit voltages, as he is sure to produce unsatisfactory welds.

C. J. Holsiag,* Newark, N. J.—Speed in welding may be advantageous or disadvantageous according as to whether the metal is deposited faster than the operator can make sure it is being deposited in the crater made fluid by the arc, or whether some of the metal is getting ahead or outside of the crater. Speed at which good welding can be done is an advantage and alternating current provides a greater speed than direct-current welding with the electrode negative, because with the electrode negative approximately 60 per cent. of the heat is in the work, and with alternating current the heat is naturally fifty-fifty between the electrode and work.

[1] Presented at session with American Institute of Electrical Engineers. Printed in A. I. E. E. *Proceedings*.

* Electric Arc Cutting & Welding Co.

Direct current with the electrode positive provides faster welding, but generally too fast to be of any use, as mentioned, unless the arc is closed in by a very heavy coating so that the metal is enclosed in a viscous sleeve, or where the work is very rough, such as filling in with a large electrode on a casting where strength is not required. In a test recently made with direct-current and alternating-current machines, the rate of melting was taken; that is, the number of pounds per hour that could be melted with no stops was determined. In each case under the same conditions, *i.e.*, different currents and voltages were taken, but comparisons made only when they were the same, alternating-current melting was from 20 to 30 per cent. faster. For instance, at 150 amp. and 25 volts, 4 lb. an hr. were deposited with alternating current and 3 lb. an hr. with direct current; and at 175 amp. and 25 volts, 5 lb. an hr. with alternating current and 4 lb. an hr. with direct current. With a 5/32-in. electrode, from 4 to 5 lb. an hr. is the maximum amount that can be deposited in electric arc welding, for with higher current densities good welding is lost.

Speed also depends on the length of the arc because the rate of melting depends on the rate of heating and the rate of heating naturally depends on the voltage across the arc, as well as the current through it. With a long arc, this rate can be raised, and hence the welding speeded up; but as pointed out in Mr. Eschholz's paper, everything is in favor of a short arc for good welding, *i.e.*, less air radiation, less contact with the air for oxidation and forming of nitrides, greater chance that metal of the electrode will deposit in the crater and nowhere else. With alternating-current apparatus, the greater possibilities for automatically holding a short arc, and constant rate of heating are generally taken advantage of. Hence any test of speed must be accompanied by voltage across the arc and amperes through it, which means by definition, the same rate of heating; and with the same rate of heating, the only factor left is the disposition of the heat at the positive and negative electrodes, for as explained before, the amount of heat at the electrode end determines the rate of its melting.

W. L. MERRILL,* Schenectady, N. Y.—Until about 2 years ago, spot welding was limited to very thin sections, say up to 1/4 or 3/8 in. (6 or 9 mm.) thick; beyond that the field had not been thoroughly explored. It was thought that it might be advantageous to use this method in the construction of ships, so tests were made and a machine built, the results of which have been published in Capt. Caldwell's report and in one issue of the *General Electric Review*, which has been referred to by Mr. Hobart. As a result of those tests, it was found possible economically to build machinery capable of welding two or more pieces of structural steel up to a total of 3 in. that being the maximum thickness we tried to weld.

Unlike arc welding, spot welding has very few variables; and a surface

* Engineer, Power & Mining Engng. Dept., General Electric Co.

inspection in practically all cases is all that is necessary to determine a 100-per cent. weld. Also, like the arc weld that we have been hearing about today, spot welding can be done to more than 100 per cent. strength of the plate. As an example, page 548 contains some test samples that were made up of different kinds of welding. The two-spot weldings, which would be used for these thicknesses of plates, gave a breaking strength of 28,000 lb. as against 13,000 lb. for the standard riveting for that same plate.

As a result of experiments carried on in the large machine, which by the way was 2000-k.v.a. capacity, although we did not reach the capacity of the machine, three separate and distinct machines were designed for use in fabricating of ships; that is work to be done in the shop, not on the ships. Pictures and explanations of these are given in Mr. Hobart's paper. These machines have been completed, and two of them are in the possession of the Emergency Fleet Corpn. at the present time, working out the practicability of adapting them to the fabrication of ship parts in place of laying out, drilling, and riveting. Only experience will tell what saving or gain, if any, there will be in the use of this type of machinery. One thing, however, we know can be gained, and that is for a given strength of a given member, the joints will not be limiting features, and if 60 per cent. is figured for riveted joints, the thickness of the plate can be reduced proportionately because you are always sure of 100 or more per cent. strength if spot welding is done with proper care.

D. C. Alexander, Jr.,* Brooklyn, N. Y.—In mining work, manganese steel is used for rails, crossovers, and, I believe in some cases, wheels on mining cars. Now, for that sort of work it has been customary, when the manganese steel parts wore out, to scrap them because there seemed to be no way of repairing them. A covered electrode, if it is properly covered, will deposit the slag on the molten metal so that the constituents of the original metal can be retained in the positive metal. So by starting with a high manganese-steel wire and putting the suitable covering on that wire, it is possible to deposit on a plate, or manganese specimen of some sort, 12 per cent. manganese steel. That in itself justifies the covered electrode for that particular kind of work. I imagine mining engineers may have occasion to build up worn parts composed of high-carbon steel. The same effect can be produced by using a 0.7 per cent. carbon steel wire, and depositing 0.5 per cent. carbon steel, to build up carbon steel parts.

The remarks made this afternoon about covered electrodes have been a little bit vague in some cases, and possibly some of you have the idea that any kind of covering on an electrode produces the same result. I noticed in Mr. Hobart's paper that, in some instances where it did not give satisfactory results, a great improvement could be made by dipping

* Quasi-Arc Weldtrode Co., Inc.

the wire into the melted iron. That may be correct, and some people may think they will get a big improvement in that way. But when you think about it, you must realize that in steel-furnace practice you must have a suitable slide, you cannot have any kind of slide; similarly the material used as electrodes must not be selected because it is cheap or common, but because it is the only one found to contain the proper constituents. What we use is blue asbestos, which is not like white asbestos at all. The coating fuses with the steel and covers the molten steel with a thin slag, which keeps out the oxygen and prevents the formation of oxide. It also maintains in the molten metal the constituents of the steel that we want to keep there.

W. SPRARAGEN,* New York, N. Y.—I would like to call your attention to a slight typographical error in Table 3, page 547. The current given for the 60° bevel should be 125 instead of 168 amp. The angle referred to in this table is the angle on each plate, therefore the total opening in each weld will be just double that given. For instance, the total opening for the 15° bevel listed in this table would be 30°. The statement is in connection with article 24, on page 546, and Mr. Hobart states that no physical test has been made on these samples. I have, however, received from the Electric Testing Laboratories some results of tensile and bending tests on these specimens; each result given below is an average of three test specimens.

Angle of Bevel on Plates, in Degrees	Total Opening, in Degrees	Ultimate Strength, in lb. per Sq. In.	Angle of Bevel at which Crack Starts, in Degrees
15	30	44,000	9
30	60	51,000	15
45	90	45,300	13
60	120	48,800	14

These results seem to indicate that the advantages claimed by the American traditions for the very large opening are rather questionable if we also take into account the time, electrode material, and power saved by the smaller angle of bevel, as shown in Table 3. Obviously one could have too small an opening so that the operator would not have sufficient room in which to properly manipulate his electrode. The results of the above test would indicate that this point was reached when the total opening was 30°.

J. C. ARMOR, Pittsfield, Mass. (written discussion†).—Mr. Hobart has presented a comprehensive list of points that are of vital interest in fusion welding. In connection with his 4th point, page 527, Preferable Composition for Bare Welding Wires, would say that in alternating-current arc welding of steel plates with bare electrodes good sound welds

* Electric Welding Research Assistant, American Welding Society.

† Received Feb. 19, 1919.

can be produced with wire that is composed of practically pure iron alloyed with from 0.02 to 0.65 per cent. manganese. The brands of welding wire that contain 0.30 to 0.60 per cent. manganese will generally produce the strongest welds, while those carrying a very small amount of manganese will, in general, produce the softest welds. I have not had much success with wires carrying more than 0.65 per cent. manganese or with alloying elements other than manganese.

In connection with the 7th, 8th, 10th, and 11th points, would say that there is very little, if any, difference in the quality of work done with alternating current and direct current, provided, of course, that proper conditions are maintained in both cases. It is as easy to work with alternating current as with direct current, provided the alternating-current "striking" voltage is sufficiently high. Any commercial frequency is suitable for arc welding if sufficient open-circuit voltage is employed. The lower frequencies require somewhat higher voltages. My experience indicates that the speed of welding is about the same with alternating current and direct current. An operator who is experienced in direct-current welding usually adjusts his alternating current to a value that allows him to manipulate the fused metal in the way he has always done with direct current, with the result that he melts in about the same quantity in a given time.

In connection with Mr. Hobart's 20th point, Effect on Arc Welding of Voltage Employed, it is, of course, a well-known fact that the alternating-current arc is much more easily extinguished than the direct-current arc and also that the lower the frequency the more easily is the arc interrupted. These facts must be taken into account in welding with alternating current. The general tendency has been to employ alternating potentials of too low a value for effective work, with the result that the operator cannot manipulate his arc properly and therefore has difficulty in producing good work. This question of open-circuit potential is extremely important; and if it is desired to be free to use all welding wires now on the market, the "striking" voltage for 60 cycles should be at least 150 volts. Good welds can be made with less voltage when using certain brands of wire but other brands will require 150 volts. When the voltage is too low, there is a very strong tendency to hold the arc between the electrode and the top, or outside, of the weld, with the result that the metal at the bottom of the weld is not fused in as well as it should be. Arc welding, even under the best possible conditions, is very trying to a conscientious operator and for that reason the work should be done in the easiest practicable manner, as it is impossible for an operator to do uniformly good work if he is under a continuous strain. While an expert may make a few very good test welds, using a potential so low that he has the greatest difficulty in working, he will not be willing to work that way day after day; and if required to do so he will tend to become discontented and careless. For the reason just given, the alter-

nating-current potential employed for most commercial wires now on the market should, in the writer's opinion, be about 140 or 150 volts.

In regard to Mr. Hobart's 28th point, Consequences of Different Lengths of Arc, the writer's experience has been that the shortest practicable arc produces the best welds. A long arc, on the other hand, deposits inferior and weak metal in the weld. No doubt this is due to the absorption of larger amounts of oxygen and nitrogen from the air. The question of arc length is certainly as important as the electrode composition and the secret of good welding with most of the commercial wires now on the market is found in the maintenance of a very short arc manipulated so that the deposited metal fuses into the plate over the whole surface to be welded.

S. V. GOODALL* (written discussion†).—The thanks of those interested in welding are due to Mr. Hobart for this valuable paper.

Mr. Hobart omits to refer to the investigations carried out by the Welding Research Sub-committee to ascertain whether any trouble is to be expected from excessive corrosion of a welded joint exposed to sea water. The point was raised, early in 1918, that on account of the difference in chemical composition and electrolytic characteristics of mild-steel ship plate and the metal laid on at the weld, it is possible that excessive corrosion would set in at the joint if the protective and anti-fouling compositions were accidentally removed or otherwise rendered ineffective, and the joint might fail in consequence. As welding had already been employed for effecting repairs to under-water parts of ships, the Welding Research Sub-committee instituted inquiries to ascertain whether excessive corrosion had been experienced in these cases; and while few replies were received, owing to the fact that the history of the weld after the repair was effected had not been kept, no actual cases were cited where excessive corrosion had occurred.

The British Admiralty and the U. S. Navy Department are carefully watching the effect of sea water on welded joints, and under the superintendence of Commander H. G. Knox of the U. S. Construction Corps, a series of tests on the corrosion of welded joints made with various types of electrodes is being carried out at the Norfolk Navy Yard. The Bureau of Standards is also investigating this matter. So far the experience at present available and the opinions obtained lead to the conclusion that no danger need be feared from excessive corrosion of a weld on service; further experience, however, is considered necessary before this question can be regarded as definitely settled.

With regard to the application of spot welding to shipbuilding, Mr. Hobart states that it is planned that bulkheads, frames, floors, and other parts shall be spot-welded and then transported to their places in the ship. This sounds attractive; but the shipbuilder will at once ask how the cost of such spot welding compares with that of riveting. The

* Constructor-Commander, N. N.

† Received Mar. 5, 1919.

riveting of parts such as those mentioned can be done in shops or sheds, and is comparatively inexpensive. If it is to be displaced by spot welding, this latter process must be considerably cheaper than I understand it to be; and if Mr. Hobart could add particulars as to the relative cost of spot welding and riveting such members, it would add to the value of this part of the paper. With regard to the adoption of spot welding for work at the ship, there are many difficulties ahead for those shipbuilders who attempt this work; this opinion is based on experience with portable hydraulic riveters in ship construction and is altogether apart from the practicability, or otherwise, of efficiently connecting two heavy plates by spot welding. Even in this latter respect it must be remembered that there is considerable difference between the spot welding of two small thick plane plates in a shop and the spot welding of two large non-planar plates forming the complex structure of a ship. Moreover, spot welding, compared with line welding, possesses the disadvantage that economy of steel is not likely to be so great.

Mr. Hobart, in presenting the paper, rather ineffectively trailed the coat-tails of the bare-wire advocates in the face of those who believe in covered electrodes. In Great Britain, shipbuilders and engineers are not paying the additional price of covered electrodes for philanthropic reasons; as soon as they are convinced that the bare electrode will give as good and as uniform results as the more costly covered wire, Mr. Hobart may rest assured that the bare electrode will be freely used in that country. But I am bound to say that present experience in Great Britain indicates that the covered electrode gives superior results and gives such results more uniformly, the superiority being particularly indicated in fatigue tests, which is an extremely important matter if welding is to be employed on parts of ships contributing to general structural strength. Mr. Hobart states that one type of electrode must yield results uniformly superior to those obtained with another type in order to afford economic justification for a five times greater price. It is not considered that this matter can be summed up in this manner in regard to shipbuilding if electric welding is employed on such parts that the resulting joint is of importance in the general structural strength. If, by using a high-priced electrode, the desired minimum standard of strength can be always attained with certainty, while the lower priced electrode cannot be relied on to attain such a standard at all times, the shipbuilder would not be justified in using the cheaper article, unless it were possible to subject all the joints to some test that would imitate in quantity and quality the forces that will be brought upon the joints on service. The cost of such tests might offset the lower cost of bare electrodes. Moreover, if two different types of electrodes were used on a ship—the cheaper where strength is not of much importance and the more expensive where structural strength is vital—extremely careful supervision would be necessary, and it would probably be more practi-

cable for the shipbuilder to adopt the higher priced article throughout.

It is desired to emphasize point 30 of Mr. Hobart's paper, on the necessity of a clean surface for fusion welding. Some of the unsatisfactory work that I have seen is due to the attempt to weld together plates, etc., having surfaces that are oily or are otherwise insufficiently clean.

R. P. JACKSON,* Pittsburgh, Pa. (written discussion†).—Both the varied and somewhat conflicting information set forth in Mr. Hobart's paper and that obtained by observation and experience indicate that in a large measure electric welding is an art rather than a science. While it is obvious that a great deal can be done in the way of eliminating the useless and fake elements, after all that a scientific investigation can contribute has been taken into account, the actual production of safe welds is essentially a personal problem. A skillful welder will do some very creditable work with a variety of materials and equipment and an unskillful one will do poor and unreliable work with the most perfect equipment.

It is this feature of the essential dependence on the skill of the individual welder that has been such a handicap to the more extended use of welding. The difficulty is that a designing engineer laying out his computations and drawings cannot know with any degree of certainty what he can depend on in the way of a joint as compared with riveted work put up with a very moderate degree of skill but capable of being checked by inspection.

While this comment does not disparage the necessity of research work and particularly of a greater degree of publicity as to the actual facts, its purpose is to accentuate the necessity of training welders and inspectors. The writer feels that no extensive undertaking like shipbuilding can be worked out except as a result of the building up of a welding organization, comprising a superintendent, inspectors and welders who are conscientious and know their job. Without such an organization, no cautious engineer would specify the use of welding for the obvious reason that he could not be sure what he would get. With such an organization, on the other hand, there is almost no engineering structure that could not be undertaken, with the only limitation as to the amount of welding to be the accessibility of the assembled structure for the proper welding operation.

Static, Dynamic and Notch Toughness

Discussion of the paper of S. L. HOYT, presented at the New York meeting, February, 1919, and printed in *Bulletin* No. 146, February, 1919, p. 339.

J. A. MATHEWS,‡ Syracuse, N. Y. (written discussion§).—This paper by Prof. Hoyt, together with the papers by Messrs. Jeffries, Clayton, Rawson, and Moore, submitted at this meeting, constitute a valuable

* Research Division, Westinghouse Elec. & Mfg. Co. † Received Mar. 6, 1919.

‡ President, Halcomb Steel Co. § Received Feb. 18, 1919.

symposium on what might be called the "mechanism of failures." Prof. Hoyt has not emphasized too strongly the importance of the notched-bar test, or the notch as a feature of a structural design. There has been a good deal of misunderstanding in reference to the value of the notched-bar test, and various vibratory tests such as the Wohler, White-Souther, Stanton, and Upton-Lewis have been devised. This form of testing has received more attention abroad than it has here, and has been the subject of a great many very careful investigations. I have heard many expressions of surprise at the apparent lack of agreement between the results of vibratory tests and the results of shock tests. It is not necessary that the values obviously should agree, because obviously different properties are being tested.

In reference to the presence of notches or sharp corners in the construction of machines or parts, would say that these more frequently lead to fatigue failures than to typical notch-bar failures due to sudden impact. I have seen a number of airplane crankshafts that had apparently failed due to a keyway that was left with fairly sharp angles at the bottom. The material satisfactorily responded to every test, including the notched-bar test, nevertheless the shafts failed, showing a fatigue break, usually spiral and sometimes making at least one complete turn around the shaft.

The lack of concordance between supposedly duplicate notched-bar tests in my experience has been most often due to lack of care in the machining of the test piece itself. Prof. Hoyt draws attention to a report of Charpy in 1909, in which two steels of almost identical physical properties show very different results in the notched-bar test. He states that the microstructure at once showed that one steel was in poorer condition than the other. More recent experience has shown other cases of this kind where not even the microstructure serves to reveal any startling differences in structure.

The notched-bar test serves admirably to detect faulty heat treatment, as well as to detect defects in the material itself. The typical alloy steels for the most part have a fairly wide range within which heat treatments can be performed without showing any marked differences in the ordinary tensile qualities. When the temperature becomes too high there is apt to be a falling off in elongation and reduction, but not very marked. The differences in the shock-resisting qualities, however, are much greater than would generally be supposed from examination of the tensile-test data.

The true function and differences between vibratory and notched-bar tests are very clearly pointed out in a letter from Dr. T. E. Stanton, of the National Physical Laboratory, a copy of which was furnished me by Sir Robert Hadfield. Dr. Stanton says: "In the first place it may be mentioned that the determination of the fatigue range of stress will involve generally about five or six separate tests on similar specimens prepared

from the same bar. For the preliminary test a range of stress is chosen which will cause the failure of the specimen after about, say, 100,000 reversals. For the succeeding tests, this range is gradually reduced until the maximum range is found for which no failure will take place for however long the test is carried on. I think there can be no doubt that this maximum range of stress for an unlimited number of repetitions is the most valuable strength characteristic of the material which a designer of structures or machines can possess.

"In the second place, it must be fully recognized that the test does not attempt to discriminate between brittle and tough materials, which is, of course the function of impact testing. Considerable criticism has been passed on the fatigue tests because material which is known to be brittle often gives a high value of fatigue range of stresses. This criticism, however, is based on an imperfect knowledge of the limitations of the test."

Please note the expression Dr. Stanton uses, namely "the fatigue range of stress." In fatigue tests, so far as they have been considered for the most part in this country, we have considered a single value or determination by any of the numerous methods of vibratory tests as an indication of quality or properties in itself, just as we would speak of a Brinell hardness number. The use which Dr. Stanton proposes for this test is apparently quite different. He states the true function of the fatigue test to be "the determination of the maximum working stress to which material may safely be subjected in practice," and he presupposes that the material has a satisfactory microstructure and that the toughness, as revealed by the notched-bar impact test, is sufficient for the purpose for which the material is to be used.

Prof. Hoyt's paper is dealing primarily with external notches. In my judgment, an even more important consideration is internal notches in the form of flakes, slag inclusions, bursts, pipes, and all kinds of interior defects. The external ones can be seen and avoided; the internal ones are more difficult to detect. In this connection, I would like to call attention to a most interesting paper by Dr. Andrew McCance, entitled "Non-metallic Inclusions and Their Constitution and Occurrence in Steel," which was presented at a meeting of the Iron and Steel Institute of Great Britain in May, 1918. I will quote the opening paragraph of this paper, which is very striking:

"The important part which non-metallic inclusions play in causing failures and producing defects in all manner of steel products is not yet fully realized. Much defective steel is bad solely because of the number of non-metallic particles which it contains, and fully 90 per cent. of the failures due to faulty material, which have come under the author's notice, have been traceable to this cause alone."

There is food for much thought in that paragraph, and subsequent

discussion by the author, showing how these inclusions may be and are a potential source of failure, is worth serious study. The most minute of these inclusions may lead to what have been designated as hair lines. These are so minute that they only appear on the ground and finished surface, and often require a lens for their detection. The number of them present in different steels varies tremendously. In a series of tests made by grinding and inspecting large surfaces, the relative frequency of hair lines was about as follows: In basic open-hearth steel an average of 46 hair lines was noted; in acid open-hearth steel, the average was 23; and in electric steel, the average was 6. In a great many electric heats that I have seen tested in this way, no hair lines whatever were detected. Not only the number, but the relative size of the hair lines was very different in the electric from those seen in the open-hearth steels; they were very much shorter and less conspicuous, as well as less frequent.

It is my opinion that if designers were fully acquainted with the materials they were using they could design much lighter parts, because they would be able to design with reference to a fairly definite factor of safety, whereas at present they mostly employ a generous factor of ignorance. It has taken the very serious jolt of the war to bring about the intensive study and coöperation in regard to these problems which we see today, and this has brought about an appreciation of high quality in materials that did not formerly exist.

Paul D. Merica,* Washington, D. C. (written discussion†).—Prof. Hoyt has well emphasized the danger of failure in ferrous materials

Fig. 1.—Etched section of naval brass rivet fractured in service.

of construction that attends the simultaneous presence of sharp offsets in section, or notches, and a thoroughly crystalline structure of the net-work type. This combination is found to be a dangerous one also in non-ferrous materials. Thus in an investigation made several years ago of a number of failures of brass and bronze[1] a number of naval brass

* U. S. Bureau of Standards. † Received Feb. 7, 1919.

[1] P. D. Merica and R. W. Woodward: Failure of Brass. U. S. Bureau of Standards, *Tech. Paper* No. 82 (1917).

rivets were examined, some of which had stripped off at the head during several months, others of which, however, had remained intact. It is obvious that the offset at the shoulder or head of the rivet forms a sharp angle at which tensile stresses on the rivet are severely localized, and those rivets that had broken, broke at this point. The photograph shows the structure typical of those that broke; the metal consisted of grains of the beta surrounded by complete envelopes of the alpha constituent. The fracture was intercrystalline and along these envelopes. The majority of those rivets that had not broken, but which had been removed for examination, showed a quite satisfactory and fine structure free from gross network.

I have, elsewhere,[2] called attention to the significance of the notch in determining the phenomenon of corrosion cracking in brass and bronze. It appears that corrosion is much more severe at the bottom of sharp notches or offsets in such materials than at other parts, when the article is under tensile stress, and may actually determine failure at such points if the stresses are severe. H. S. Rawdon[3] has corroborated this fact in the course of some very interesting studies on the corrosion of Muntz Metal.

GEORGES CHARPY,* Paris, France (written discussion†).—We have read with much interest Prof. Hoyt's paper on the toughness of steels considered from the new points of static or dynamic tests, and of notch tests. Prof. Hoyt has ably presented the question, illustrating with the most convincing photographs, and metallurgists will thank him for his work.

Influence of the Speed of Impact.—The writer believes that one should guard against exaggerating the importance of the influence of the speed of test. It seems to have been proved, by numerous experiments, that when the test is kept within practical limits the speed does not exert a preponderating influence. The results of the static test differ much from the results of the dynamic test, but the proved differences do not exceed a few units per cent. in the most favorable conditions; that is, they are of the order of magnitude of the differences observed from one experiment to the other in the same series.

About 15 years ago, the writer made some tests on resistance to impact in which the ram (drawing with it the resisting bar) fell about 50 m., with a speed of impact of about 30 m. per sec. The energy absorbed by the rupture in these conditions did not differ notably from the energy absorbed in the course of the test on the static machine

[2] P. D. Merica: Failure of Brass. U. S. Bureau of Standards, *Tech. Paper* No. 83 (1916).

[3] Typical Cases of the Deterioration of Muntz Metal by Selective Corrosion. U. S. Bureau of Standards, *Tech. Paper* No. 103 (1917).

* Member, *Institut de France.*

† Received Feb. 13, 1919. Translated from the French.

(length of test = 1 min.) calculated diagrammatically. For the notch tests, the question seems to present itself in the same manner. Attention was attracted 20 years, or more, ago to the factor of speed by the experiments of Considère, but the results of these seem to have been falsified by an error of interpretation, and it would seem wise not to take them into account.

Influence of Treatment of Materials on Results of Impact Test.—The author has very ably brought forward the importance of effect of the treatment undergone by the steel on the manner in which it behaves in an impact test; it is an observation that the writer has often made. A metal, even if it is not of exceptional quality, being given the coefficients of safety ordinarily admitted, if it is well treated, can furnish pieces that will give excellent service. On the contrary, if metal is not treated at all, or is treated in a wrong way, even though it may be sound and unalloyed, it will furnish very unsatisfactory pieces. The impact test on notches seems to the writer valuable for discovering this absence of treatment, or defects in the treatment because, of all the ordinary tests, it is the only one that shows these points with exactness.

That is the reason that the writer believes, with the author, that the localization by the notch in a specified section is an essential condition of the impact test. It is not necessary to seek the local faults that may be shown by other methods, but only to point out precisely the physical state as a whole of the metal constituting the piece to be tested. It is therefore necessary to make the test on a deliberately chosen region, and to shield oneself as much as possible from the local accidents that falsify the results as a whole.

Definition of Notch.—The author describes judicially the influence of the shape of the notch on impact tests; the writer believes that it would be a considerable advantage in comparing experiments if the notches were rigidly standardized. All observers, at the present time, seem agreed in recognizing that the bar of 10 by 10-mm. section is the best adapted to the current practice of the workshop; the lengths employed vary scarcely more than from 53.3 to 60 mm. But we find, in scientific literature, an amazing diversity in the shape of the notches; some use the sharp-pointed superficial notch; others, the deep round notch; and all intermediate types are represented. How, under these conditions, can we compare the results obtained in one laboratory with those of another; the results of one experimenter with those of another?

After a long series of tests and of practical observations, the writer believes that the best notch is the deep one (mid-thickness), and round. It seems to present the following advantages: (1) It can be determined with the greatest exactness, since it can be obtained with the drill. (2) Like all deep notches, it reduces in the whole work of rupture, the proportion of the work of bending in reference to the work of detaching

rivets were examined, some of which had stripped off at the head during several months, others of which, however, had remained intact. It is obvious that the offset at the shoulder or head of the rivet forms a sharp angle at which tensile stresses on the rivet are severely localized, and those rivets that had broken, broke at this point. The photograph shows the structure typical of those that broke; the metal consisted of grains of th beta surrounded by complete envelopes of the alpha constituent. Th fracture was intercrystalline and along these envelopes. The majority those rivets that had not broken, but which had been removed for exa nation, showed a quite satisfactory and fine structure free from gr network.

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the surfaces, this last being the most interesting in the phenomenon of fragility. (3) Its making does not affect the physical state of the metal around it (hardening undergone by the steel in the case of notches made by the wedge).

In the writer's opinion, a capital point will be accomplished the day that the different experimenters adopt one style of notched bar. As noted in the preceding, the writer favors a bar 10 by 10 by 60 mm., with a round notch 3 mm. in diameter and 5 mm. deep. This notch was recently defined by a sub-committee specially appointed by the French Commission for the Unification of Terms of Reference. This sub-committee was composed of M. Mesnager, Chief Engineer of Bridges and Roadways, Director of the Laboratory of Bridges and Roadways in Paris; M. Cellerier, Director of the Testing Laboratory of the Conservatory of Arts and Trades in Paris; and M. Charpy, General Secretary of the Commission for the Unification of Terms of Reference.

INDUSTRIAL SECTION

This department is devoted to material concerning the products or operations of manufacturers, which, in the estimation of the Editor, is of news value to the mining and metallurgical field but does not come within the scope of the main editorial section of the Bulletin.

Manufacturers are invited to submit to the Editor items descriptive of new equipment or processes, large or significant installations, and similar material of news character. If found available, items thus furnished will be published in this section without charge, subject to such editorial revision and condensation as may be necessary.

In cases where illustrations are required, cuts of the proper size should accompany the text matter.

"RAPID" ELECTRO-MAGNETIC ORE SEPARATORS

The magnetic separator for treating ores permeated with strongly magnetic and feebly magnetic materials is increasingly being recognized as a necessity in the concentration of ores whose specific gravities are too much alike to allow of separation by means of concentration on tables. The Rapid Magnetting Machine Co., Ltd., of Birmingham, Eng., claims to be the first firm in the British Empire to put on the market a magnetic separator, of British invention and manufacture, for the separation of feebly magnetic ores; for instance, wolfram-tin, wolfram-bismuth, monazite sands, zinc blende, etc.

The "Rapid" Type O electro-magnetic three-pole three-disk separator consists of a three-pole powerful electro-magnet stationed under an endless traveling rubber feed belt, on to which the ore is fed in a thin even stream, or layer, passing the pole pieces successively. Above the belt, adjustable laterally and vertically from the first pole, is a horizontal disk of larger diameter than the width of the belt. The edges of this disk immediately over the belt are magnetized by induction sufficiently to attract iron and highly magnetic material from the ore on the feed belt, which, as the disk revolves, is carried on its edge out of the magnetic influence, and, when overhanging the belt, falls off by gravity and is there collected. The first edge is of lowest intensity; the second, of slightly higher intensity. The ore passes along until it reaches the second revolving disk, which is situated above and between two of the magnet poles, where the magnetic lines of force are concentrated through the feed belt and ore to the disk, which is shaped so that an intense induced magnetic field is produced on its edges on that section actually over the magnet poles, attracting the coarser feebly magnetic material, carrying and depositing it while overhanging the edge of the feed belt where the magnetic influence is nil, or the change of polarity causes its release.

LEYNER OIL FURNACE, NO. 3

The combustion chamber is a peculiar and distinctive feature of the Leyner Oil Furnace, sold by the Ingersoll-Rand Co., New York. It insures an intimate mixture of vaporized oil and air in the lower part of the chamber, where they are heated to such a point that complete combustion takes place in the upper part of the chamber, the gases burning with a blue transparent flame in close proximity to the tools to be heated. The lining consists of six pieces of the very best heat-resisting material obtainable and is of such shape as to be easily placed. The front tile is cut out on top to conform to the casting while the back tile is carried

up to the full height and provided with an opening to receive a renewable plug against which the flame impinges.

The burner of the low pressure type is comparatively noiseless in operation, and will operate equally well on air supplied from a low-pressure (12 oz. to 20 lb.) or high-pressure (20 lb. or higher) source. If low-pressure air is used, the burner is equipped with larger pipes and valves leading to it. To enable the operator to secure a very short heat on the drill steel, a flame blower has been attached to the front of the furnace. This is a perforated air pipe arranged to direct the heated gases toward the back of the combustion chamber, so that the steel is heated only at the point where the forging is to be done.

INDUSTRIAL NOTES

The Traylor Eng. & Mfg. Co., of Allentown, Pa., is building for the Michigan Limestone & Chemical Co., of Rogers City, Mich., the largest gyratory crusher that has been turned out of any plant. It has a 60-in. opening and a capacity of 3000 tons per hour.

The New Jersey Zinc Co. has removed from its quarters at 55 Wall St. to 160 Front St., New York.

The A. J. Meier Co. has removed its offices to 1903 Boatman's Bank Bldg., St. Louis, Mo.

TRADE CATALOGS

(Under this heading will be listed such catalogs or other advertising literature as may be received during the preceding month. Contributors should address their material to Engineering Societies Library, 29 West 39th St., New York.)

Arthur Knapp Engineering Corpn. New York, N. Y.
Modern thread inspection equipment. 1918.

Baldwin Locomotive Works. Philadelphia, Pa.
The Fifty-thousandth Locomotive. Record No. 92. 1918.

J. P. Devine Co. Buffalo, N. Y. Vacuum chamber dryers. Bulletin 101A.
High efficiency perfectly balanced vacuum evaporators. Bulletin No. 106.
High efficiency vacuum pumps. Bulletin No. 107.

General Electric Co. Schenectady, N. Y.
Bulletin No. 40400B. Belt-driven alternators. Form PB. Jan., 1919.
Index to supply part bulletins. Jan., 1919.

National Co. Boston, Mass.
Presto holder. For engineers' and architects' offices, drawing rooms, machine shops, construction jobs, ship yards, libraries and any place where records, charts or schedules are used.
National Quick Attaching I-Beam and Channel Clamps. Bulletin 101.

Chas. A. Schieren Co. New York, N. Y.
Price list of Schieren Beltings.
The Story of Schieren Beltings. 1919.

Walworth Manufacturing Co. Boston, Mass.
The Walworth Log. Feb., 1919.

Westinghouse Electric and Manufacturing Co. East Pittsburgh, Pa.
Westinghouse alternating-current motors. Catalog 33. Dec., 1918.

THE MINING AND METALLURGICAL INDEX

January, 1919

The Engineering Societies Library is prepared to supply the original, or a copy, translation, or abstract of any paper mentioned in the following index, at the following rates:

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In the following Index, volume numbers are given in heavy-faced figures, page numbers in light-faced figures. Approximate number of words is stated.

MINERAL RESOURCES

(Except Petroleum and Gas. See also Mining Geology and Mining Practice.)

Africa

DIAMONDS, Kimberley: especially cleavage diamonds. J. R. Sutton, *Chem. News* (Jan. 24, 1919) **118**, 38–41. 3500 w. Serial.

GOLD fields—Rhodesian Development Co., Year with the. *So. Afr. Min. Jnl.* (Nov. 30, 1918) **28**, 265. 700 w. Reviews position of subsidiaries.

NICKEL. T. G. Trevor, *So. Afr. Jnl. of Ind.* (Nov., 1918) **1**, 1385–94. 5000 w. Deposits, and other sources of supply.

PHOSPHATE deposits of North Africa. D. P. Fabrega, *Min. Jnl.* (Feb. 8, 1919) **124**, 83–4. 1000 w.

RHODESIA, Mineral resources of. F. P. Mennell, *So. Afr. Jnl. of Ind.* (Oct., 1918) **1**, 1302–10. 4000 w. Gold, silver, copper, chromite, tungsten, antimony, etc. (Nov., 1918) **1**, 1411–7. 4000 w. Reviews non-metallic minerals.

Australia, New Zealand, India and China

ALUNITE deposits of Australia and their utilisation. F. W. James, *New Zealand Jnl. Sci.* (Nov., 1918) **1**, 381–2. 500 w. Review *Bull.* No. 3, Advisory Council of Science and Industry. Its use as a fertilising agent.

ANTIMONY and tungsten in Hunan. *Engng. & Min. Jnl.* (Feb. 8, 1919) **107**, 273. 225 w.

GOLD mining in Western Australia. T. Butement, *Chem. Engng. & Min. Rev.* IV. (Sept. 5, 1918) **10**, 364–8. 4500 w. Present position and outlook of the Kalgoorlie mines.

INDIA in 1917, Coal Mining in. *Coal Age* (Feb. 27, 1919) **15**, 399. 500 w. From Annual report of G. F. Adams, Chief Inspector of Mines.

NDIA during 1917, Mineral production of. H. H. Hayden, *Records*, Geol. Surv. of India, **49**, Pt. 2, 55–116.

MAGNESITE and dolomite in Australia and New Zealand. P. G. Morgan, *New Zealand Jnl. Sci.* (Nov., 1918) **1**, 359–72. 6500 w. Departmental report.

Canada

ARUPRIOR—Quyon district, Ontario and Quebec. M. E. Wilson, Canada Dept. of Mines *Summary Report*, 1917, Pt. E, No. 1727. 800 w.

BRITISH Columbia for 1918, Mineral production of. *Engng. & Min. Jnl.* (Feb. 15, 1919) **107**, 320–2. 1800 w.

COPPER ore found in Skeena District. More. *Alas. & Northw. Min. Jnl.* (Jan., 1919) **13**, 18. 400 w. Deposits in British Columbia.

GRAPHITE in Port Elmsley District, Lanark County, Ontario. M. E. Wilson, Canada Dept. Mines *Summary Report*, 1917, Pt. E, No. 1727. 5500 w.

NOVA Scotia in 1918, Production of coal in. F. W. Gray, *Coll. Guard.* (Feb. 7, 1919) **117**, 310. 700 w.

POTASH in saline waters in Saskatchewan. D. B. Dowling, Canada Dept. Mines *Summary Report*, 1917, Pt. C, No. 1721, 3–4. 350 w.

PLATINUM in Tulameen district of British Columbia, Source of placer. R. M Macaulay, *Engng. & Min. Jnl.* (Feb. 15, 1919) **107**, 303–6. 3000 w.

SURFACE deposits of Southeastern Saskatchewan. J. Stansfield, Canada Dept. of Mines *Summary Report*, 1917, Pt. C, No. 1721, 41–52. 5500 w. Coal, road materials, soils, and underground water.

Europe

ALSACE-Lorraine as a coal and ore region. Alsacia-Lorena como region Hullera y Siderurgica. *Revista Minera* (Jan. 16, 1919) **70**, 27–8. 1000 w.

MINING GEOLOGY AND MINING PRACTICE

(See also Mineral Resources)

ACCIDENT prevention, Progress in. *So. Afr. Min. Jnl.* (Nov. 16, 1918) **28**, 230. 1500 w. From *Engng. & Min. Jnl.* Essential features.

AIR in deep mines, Cooling and drying the. S. F. Walker, *Compr. Air Mag.* (Feb., 1919) **24**, 9037–41. 3000 w.

AIR of mines. Wenlock. *Sci. & Art. of Min.* (Jan. 25, 1919) **29**, 194–6. 2200 w.

AIR pockets, Utilisation of. C. E. Wuench, *Compr. Air Mag.* (Feb., 1919) **24**, 9046–8. 500 w. From *Min. & Sci. Pr.* Utilising mine air pockets in designing underground pumping stations.

ALASKA in 1918, Mineral resources and mine production of. *Alas. & Northw. Min. Jnl.* (Jan., 1919) **18**, 3–5, 12–3. 4000 w. Advance statement by U. S. Geol. Surv. Some of the more important features of the reports are abstracted.

AMERICAN Mining Congress. J. F. Callbreath, *Min. & Sci. Pr.* (Feb. 8, 1919) **118**, 186–9. 4500 w. Address before the California chapter on Jan. 15, 1919.

AMERICAN mining, Wonders of. B. L. Miller, *Bull.* Pan Am. Union (Dec., 1918) **47**, 772–91. 4000 w. Ingenious processes used.

ANACONDA Copper Mining Company. *Engng. & Min. Jnl.* (Feb. 1, 1919) **107**, 234–5. 1600 w. Financing, assets, liabilities, etc.

BARITE deposits of Missouri and the geology of the barite district. W. A. Tarr, Univ. of Missouri Studies, **3**, No. 1, 111 pp.

BLASTING gun. W. H. Cherry, U. S. Pat. 1290086. *Off. Gaz.* (Jan. 7, 1919) **258**, 17–8. 100 w.

BREATHING apparatus, Six men rescued by. J. T. Ryan, *Coal Age* (Feb. 6, 1919) **15**, 272–4. 2500 w. At Mt. Braddock mine fire.

BRITISH Columbia Government, Reports of Mining Engineers. *Canad. Min. Jnl.* (Feb. 19, 1919) **40**, 100–8. 10,000 w.

COBALT silver ores, Mining and metallurgy of. R. W. Leonard, *Jnl.* Engng. Inst. of Canada. (Feb., 1919) **2**, 86–90. 6000 w. Read at Gen. Professional meeting, Ottawa, Feb. 12, 1919.

CHILE, Veins of Chauarcillo. W. L. Whitehead, *Econ. Geol.* (Jan.–Feb., 1919) **14**, 1–45.

COLVILLE Indian Reservation, Washington, Geology and mineral deposits of. J. T. Pardee, U. S. Geol. Surv. *Bull.* 677, 10–180.

CONSERVATION of life in mines. G. Wilkinson, *Min. & Engng. Rec.* (Nov. 30, 1918) **23**, 223–4. 1200 w. Serial.

COPPER mining village, Model. *Business Digest* (Feb. 11, 1919) **23**, 188. 1000 w. Extracts from article by L. Magnusson, in *Labor Rev.*, Nov. 18, 1918.

DECISIONS on mines and mining, Abstracts of current. Report from Jan. to May, 1918. J. W. Thompson, U. S. Mines Bur., *Bull.* 172, Law Series 16. 160 pp.

DIAMOND-drilling, Technique of. J. A. Mac Vicar, *Min. Mag.* (Jan., 1919) **20**, 18–24. 6000 w. Read before Cornish Inst. of Engrs.

DRAINING mines. K. F. Brown, British Pat. 120,437. *Ill. Off. Jnl.* (Jan. 8, 1919) 3127. 70 w.

DREDGING in the Orville district, California, Possibilities of. C. H. Thurman, *Min. & Sci. Pr.* (Feb. 22, 1919) **118**, 257–8. 1000 w.

DRILL-holes, Concreting prospect. R. H. Paxton, *Engng. & Min. Jnl.* (Feb. 15, 1919) **107**, 309–11. 1200 w.

DUST abatement in mines. W. O. Borcherdt, *Compr. Air Mag.* (Feb., 1919) **24**, 9048, 9051–4. 3000 w. From paper before Nat'l Safety Council.

DUST inhalation, Effects of. J. S. Haldane, *Jnl.* Chem. Met. and Min. Soc. So. Afr. (Oct., 1918) **19**, 53–61. 4500 w. Abstract of discussion in London on June 13, 1918; *Sci. & Art of Min.* (Jan. 11, 1919) **29**, 186. 1600 w. Discussion of J. S. Haldane's paper.

ELECTRICITY in mining. L. Fokes, *Sci. & Art of Min.* (Jan. 11, 1919) **29**, 180–1. 2000 w. Serial. Present number considers types of motors, starting and special regulations; (Jan. 25, 1919) **29**, 196–7. 1200 w. Shunt motor, shunt controller and compound motor; (Feb. 8, 1919) **29**, 214–15. 1800 w.

EXAMINING and developing the mine prospect. H. T. Curran, *Engng. & Min. Jnl.* (Feb. 22, 1919) **107**, 343–8. 4500 w.

EXPLOSIONS, mine, Preventions of. *Min. & Engng. Rec.* (Nov. 30, 1918) **23**, 221–3. 1000 w. Recommendations made by the U. S. Bur. of Mines.

EXPLOSIVES. R. S. Lewis, *Min. & Sci. Pr.* (Feb. 22, 1919) **118**, 245–53. 4500 w.

FOOTWALL beds of the Far East Rand reef, Notes on. L. W. Macer, *Jnl.*, Chem. Met. and Min. Soc. of So. Afr. (Nov., 1918) **19**, 70–4. 2200 w.

FRENCH Briey-Longwy iron ore basin. *Engng.* (Jan. 10, 1919) **107**, 52–3. 2500 w. Reviews a secret German memorandum relating to the supply of iron ore.

GOLD deposition in the Bendigo goldfield. *Indust. Austral.* (Jan. 9, 1919) **61**, 71. 1000 w. From Commonwealth Advisory Council of Science and Industry, *Bull.* No. 8. F. L. Stillwell, *New Zealand Jnl. Sci.* (Nov., 1918) **1**, 383. 500 w. Reviews *Bull.* No. 4, Commonwealth of Australia, Advisory Council of Science and Industry.

GOLD-pan, Miner's. E. O. C. Ord, U. S. Pat. 1292364. *Off. Gaz.* (Jan. 21, 1919) **258**, 619. 250 w.

HOIST, coal, installations, New electric. *Coal Ind.* (Jan., 1919) **2**, 15–7. 2000 w. Cage and skip hoists.

HUMIDITY of deep mines. S. F. Walker, *Engng. Wld.* (Feb. 15, 1919) **14**, 43–5. 2000 w.

HYDRAULIC prospecting at the Rooiberg tin mines. E. R. Schoch, *Jnl.* So. Afr. Instn. Engrs. (Nov.–Dec., 1918) **17**, 61–7. 2000 w. Use on level ground.

ILLNESS, prevention among employees in mines. A. J. Lanza, *Bull.* A. I. M. E. (Feb., 1919) 435–7. 1200 w.

LAW and economics, Mining. D. Bowen, *Coll. Guard.* V. (Jan. 17, 1919) **117**, 133. 2500 w. VI. (Feb. 7, 1919) **117**, 305–6. 2500 w. Serial. Ownership of minerals in British colonies and foreign countries; *Quarry* (Jan., 1919) **24**, 5–7. 1800 w. Minerals, mines and quarries; II. (Feb., 1919) **24**, 35–9. 4000 w. Ownership of minerals.

LOCO-tractor transport system, Linking up isolated mineral districts by. F. Dutton, *Engng. & Min. Jnl.* (Feb. 15, 1919) **107**, 313–4. 1500 w.

MACHINE, Mining. N. D. Levin, U. S. Pat. 1290595. *Off. Gaz.* (Jan. 7, 1919) **258**, 140. 250 w.

MACHINE, Mining and loading. N. D. Levin, U. S. Pat. 1290591. *Off. Gaz.* (Jan. 7, 1919) **258**, 139. 200 w.

MECHANICAL mining, etc., in America. W. Hopwood, *Iron & Coal Tr. Rev.* (Jan. 17, 1919) **98**, 80. 1000 w. Abstract of paper before N. Wales Branch of Nat'l Assn. of Colliery Mgrs.

METALLIFEROUS mining in the United Kingdom. *Min. Jnl.* (Jan. 11, 1919) **124**, 20–1. 1700 w.

MIDDLEMARCH mine and mill. B. M. Snyder, *Min. & Sci. Pr.* (Feb. 8, 1919) **118**, 181–2. 1200 w. Copper mine of Arizona.

MINE cars in metal mines, Standardisation of. R. M. Raymond, *Engng. & Min. Jnl.* (Feb. 1, 1919) **107**, 200–4. 3000 w.

MOLYBDENUM mine and mill, Standard minerals. *Min. & Oil Bull.* (Jan., 1919) **5**, 73–4, 102. 800 w. In Arizona.

OPERATIONS of the Burma Mines, Ltd. A. B. Parsons, *Engng. & Min. Jnl.* (Feb. 8, 1919) **107**, 257–62. 4000 w. Lead-silver-zinc producer.

PEACE River section, Alberta. F. H. McLearn, Canada Dept. Mines, *Summary Report*, 1917, Part C, No. 1721. 14–21. 3500 w. Oil exploration.

PORPHYRY intrusions of the Michigan copper district. Thomas S. Woods, *Engng. & Min. Jnl.* (Feb. 15, 1919) **107**, 299–302. 2000 w. Arguments to prove they have considerable influence on Lake Superior copper deposits.

PUMPING—Electrical control at the Deer Trail, Automatic. L. Brandenburger, *Salt Lake Min. Rev.* (Feb. 15, 1919) **20**, 25–6. 1800 w. How a mine in Utah solved its pumping cost problem.

REGULATIONS, Ganister mine. *Quarry* (Jan., 1919) **24**, 9–10. 900 w.

ROCK quarries on D'Urville Island, Maori. J. Allan Thomson, *New Zealand Jnl. Sci.* (Nov., 1918) **1**, 321–2. 600 w.

ROADWAY with concrete blocks, Arching an underground. W. Ross, *Iron & Coal Tr. Rev.* (Jan. 31, 1919) **98**, 141. 1500 w. Read before Scottish Branch of Nat'l Assn. of Colliery Mgrs.

SHAFT timbering and a method of alignment, Inclined. Arthur Neustaedter, *Engng. & Min. Jnl.* (Feb. 22, 1919) **107**, 349–51. 2000 w.

SIGNALLING, Mine. H. Walker, British Pat. 121307. *Ill. Off. Jnl.* (Feb. 5, 1919) 3474–5. 300 w.

SIGNALLING system, Electric. Sterling Telephone & Electric Co. F. G. Bell and W. C. Davey, British Pat. 121308. *Ill. Off. Jnl.* (Feb. 5, 1919) 3475–6. 500 w.

SAFETY committees at mines. W. Walker, *Sci. & Art of Min.* (Jan. 11, 1919) **29**, 183. 1200 w. From Part II of Mines and Quarries Report for 1917.

SAFETY work in mines. H. M. Wilson and J. R. Fleming, *Sci. & Art of Min.* (Jan. 25, 1919) **29**, 198–9. 3000 w. From *Tech. paper* 103, U. S. Bur. Mines.

SHOVELING as applied to mining, Study of. G. T. Harley, *Bull.* A. I. M. E. (Feb., 1919) 571-3. 800 w. Summary and conclusions.

SHOT drilling around Thetford mines. J. W. Davis, *Canad. Min. Jnl.* (Jan. 22, 1919) **40**, 36–8. 800 w.

TEMPERATURE, Deep-seam working opens up question of reducing. M. Meredith, *Coal Age* (Feb. 20, 1919) **15**, 355. 300 w.

TRACK. Electric, of the Sydvaranger iron mines. Baneanlaeg ved Sydvaranger Malmgruber, *Tek. Uke.* (Dec. 13, 1918) **65**, 599–600 250 w.

TRANSFORMERS, Selection, installation, and maintenance of three-phase oil-cooled power. L. Fokes, *Coll. Guard.* I. (Feb. 7, 1919) **117**, 303–4. 3000 w. Serial.

TIN dredging plant, Electricity for. *Elect. Times* (Jan. 23, 1919) **55**, 55. 500 w. Read before the Royal Dutch Inst. of Engrs. Describes plant in Boeboes valley, on the Island of Banka.

TUNGSTEN ores, Experiments relating to the enrichment of. R. W. Gannett, *Econ. Geol.* (Jan.–Feb., 1919) **14**, 68–78. 3000 w.

TUNNEL, Tintic drain, and its objects. E. E. Grimes, *Salt Lake Min. Rev.* (Feb. 15, 1919) **20**, 21–3. 1200 w. Construction and possibilities.

UNITED Kingdom, Borings for oil in the. V. C. Illing, *Nature* (Jan. 16, 1919) **102**, 385–6. 2500 w.

WATER discharging from mining plants. C. C. Sherlock, *Engng. & Min. Jnl.* (Feb. 15, 1919) **107**, 311–2. 1500 w. Cases where the water flows over the property of another.

WINDING, Electric. S. A. Simon, *Iron & Coal Tr. Rev.* (Jan. 3, 1919) **98**, 16–7. 3000 w. Contribution to discussion upon John F. Perry's paper before N. of England Branch of Assn. of Min. Elec. Engrs. (Jan. 17, 1919) **98**, 71. 1000 w. Author's reply to S. A. Simon's discussion on his paper.

WINDING engine, Electric, calculations. *Coll. Guard.* (Jan. 10, 1919) **117**, 79–80. 3500 w. Serial; (Jan. 17, 1919) **117**, 138–9. 2000 w. Serial concluded.

ORE-DRESSING AND PREPARATION OF COAL

ALUMINOUS ore manufacture. General Abrasive Co., Inc. Canad. Pat. 188745. *Of. Rec.* (Feb. 18, 1919) **47**, 224. 100 w.

BISMUTHINITE molybdenite ore, Dressing. *Min. & Sci. Pr.* (Feb. 22, 1919) **118**, 253. 200 w.

COAL breaker and preliminary mechanical cleaner, Bradford. *Coal Age* (Feb. 20, 1919) **15**, 352–5. 2500 w. Construction and operation.

COLLIERY, A modern. G. Hann, *Proc.* So. Wales Inst. Engrs. (Jan. 24, 1919) **34**, 263–5, 285–8. 2000 w. Discussion of paper.

COAL tipple of the Granville mines. *Coal Ind.* (Jan., 1919) **2**, 13–4. 1000 w. At Brockwayville, Pa.

CONCENTRATING gold ores. A. R. Mackie, British Pat. 121253. *Ill. Off. Jnl.* (Feb. 5, 1919) 3454–5. 100 w.

CONCENTRATING ores. E. Edser, British Pat. 121303. *Ill. Off. Jnl.* (Feb. 5, 1919) 3472–3. 100 w.

CONCENTRATING ores. H. W. Faust, British Pat. 120811. *Ill. Off. Jnl.* (Jan. 22, 1919) 3287–8. 100 w.

CONCENTRATION at the British Broken Hill. G. C. Klug, *Min. Mag.* (Jan., 1919) **20**, 25–7. 2000 w. Describes methods.

COPPER, Hydrometallurgy of. W. N. Rossberg and G. E. Sheridan, U. S. Pat. 1292075. *Of. Gaz.* (Jan. 21, 1919) **258**, 550. 300 w.

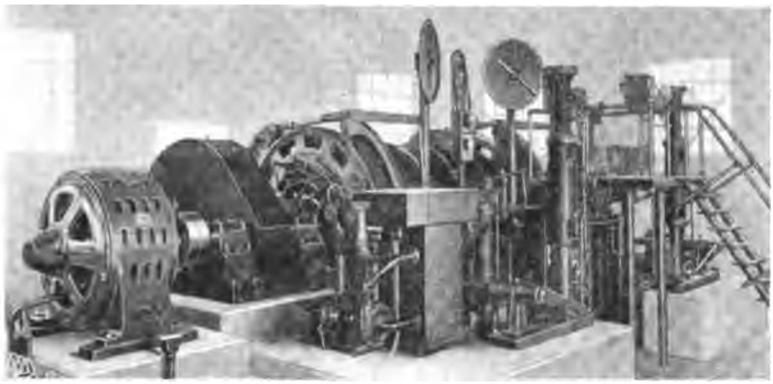
CRUSHING and grinding mill, Park. *Indust. Austral.* (Jan. 2, 1919) **61**, 15. 1200 w.

CRUSHING in ball-mills, Fine. E. W. Davis, *Bull.* A. I. M. E. (Feb., 1919) 111–56. Operating tests; mechanics of the ball-mill; ball wear.

"DRAPER" washer: the latest development in the hydraulic classification of coal and minerals. G. Knox, *Proc.* So. Wales Inst. Engrs. (Jan. 24, 1919) **34**, 291–323. With short discussion.

COAL AND COKE

(See also Mineral Resources, Mining Geology and Mining Practice, Ore-dressing and Preparation of Coal.)



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(See also Ore-dressing and Preparation of Coal, Coal and Coke, Metallurgy of Non-ferrous Metals)

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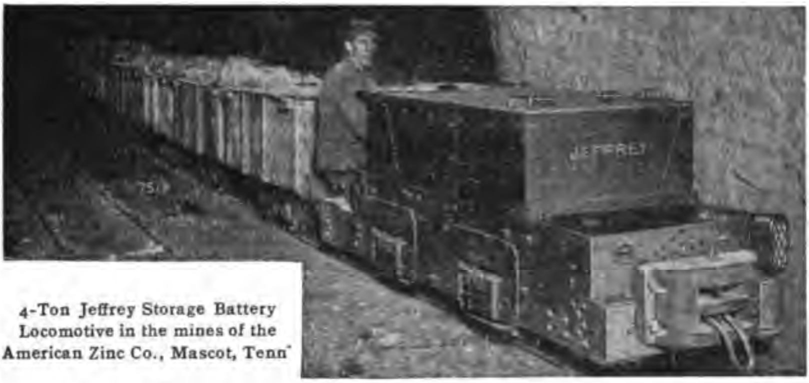

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PHOSPHORUS in vanadium steels, ferrovanadium, non-vanadium steels, and pig-iron, Determination of. C. M. Johnson, *Jnl. Indus. & Engng. Chem.* (Feb., 1919) 11, 113–6. 2500 w. Methods.

PICKLING, Removing oxide scale by. E. E. Corbett, *Iron Tr. Rev.* (Feb. 27, 1919) 64, 564–8. 4500 w. Comparison of steel cleaning liquors made of niter cake and sulfuric acid.

PIG iron after the war, Electric. R. Turnbull, *Chem. & Met. Engng.* (Feb. 15, 1919) 20, 178–9. 1800 w. Read before Electrochemical Soc. in Atlantic City, Oct. 1, 1918.

PLATE mill for Japan, Huge. *Iron Tr. Rev.* (Feb. 6, 1919) 64, 387–8. 800 w. Largest exported from U. S.

PLATE mill largest in the world, Lukens new. *Internat. Marine Engng.* (Feb., 1919) 24, 101–2. 1000 w.

PLATE mills, Electrically driven. G. E. Stoltz, *Elect. Jnl.* (Feb., 1919) 16, 69–73. 3000 w. Revised from paper before Phila. Sec. of Assn. of Iron and Steel Elect. Engrs.

PLATE rolling mill in the world, Largest. *Engng* (Jan. 24, 1919) 107, 110–2. 2000 w. Plant of Lukens Steel Co., Coatesville, Pa.

POTASH content of blast furnace charges. N. H. Gellert, *Iron Age* (Feb. 6, 1919) 103, 355–6. 1000 w. Alabama iron ores and foreign manganese ores contain the most.

POTASH from blast furnaces. *Com. Fertilizer* (Feb., 1919) 18, 60–2. 900 w. Southern iron ores a promising source.

PRODUCTION, Increased melting capacity aids. *Foundry* (Feb., 1919) 47, 69–71. 1500 w.

PULVERIZED coal for metallurgical furnaces. C. E. Longenecker, *Iron Age* (Feb. 6, 1919) 103, 351–2. 500 w. Greater efficiency claimed.

QUENCHING experiences, Surface factor in. L. H. Fry, *Page's Engng. Wkly.* (Jan. 18, 1919) 34, 45. 700 w. Abs. of paper before British Iron and Steel Inst.

RAIL mill practice, Some pointers on. W. S. Standiford, *Canad. Machy.* (Feb. 6, 1919) 21, 138–48. 4500 w. Analysis of modern methods with particular reference to roll designing and shrinkage problems.

REMINISCENCES. P. Kreuspointner, *Proc.* Steel Treat. Research Soc. (July, 1918) 1, 51–4. 3500 w. Reviews metallurgical progress in steel treating.

RESISTANCE of materials. Cause of premature rupture of pieces of steel under repeated strain. Résistance des matériaux. Cause de la rupture prématurée des pièces d'acier soumises à des efforts répétés. Ch. Frémont, *Génie Civil* (Jan. 18, 1919) 74, 47–52. 1900 w.

RESISTANCE of steel to fatigue under reversed stress, Effect of cold-working and rest on. H. F. Moore and W. J. Putnam, *Bull.* A. I. M. E. (Feb., 1919) 391–404.

RIVET steel, Structure and strength of overheated. S. H. Graf, *Engng. News Rec.* (Feb. 6, 1919) 82, 280–2. 1200 w. Embrittling effect made clear.

ROLLING mill. V. E. Edwards, U. S. Pat. 1290942. *Off. Gaz.* (Jan. 14, 1919) 258, 249. 50 w.; and U. S. Pat. 1290943. 249–50. 150 w.

RUSTING of iron and steel, Effect of rolling on. H. Y. Carson, *Engng. & Contr.* (Feb. 26, 1919) 51, 225. 1000 w. From discussion of a paper on Bridge Inspection, before Brooklyn Engrs' Club.

RUSTLESS iron, Lost secret of. *Brass Wld.* (Feb., 1919) 15, 49. 250 w.

RUST proofing of iron and steel. E. S. Whittier, *Metal Ind.* (Feb., 1919) 17, 79–82. 3500 w. Parker rust proof process.

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SILICA brick from roof of a basic open-hearth furnace after 135 charges, Seasoned. C. S. Graham, *Fdy. Tr. Jnl.* (Jan., 1919) 21, 42–4. 1500 w. Chemical analysis and specific gravity determinations.

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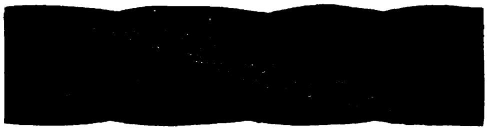

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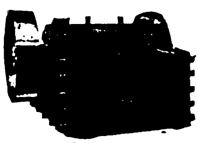

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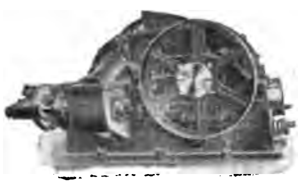

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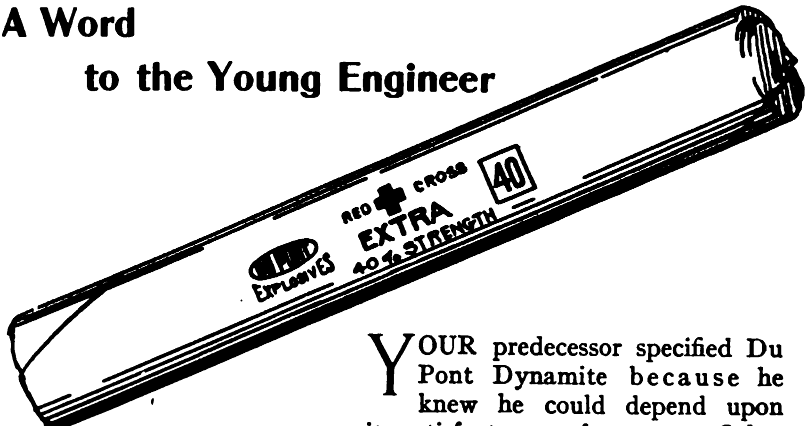

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Engines, Corliss
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Nordberg Mfg. Co., Milwaukee, Wis.
Vulcan Iron Works, 1744 Main St., Wilkes-Barre, Pa.

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Worthington Pump & Machinery Corp'n., 115 Broadway, New York City.

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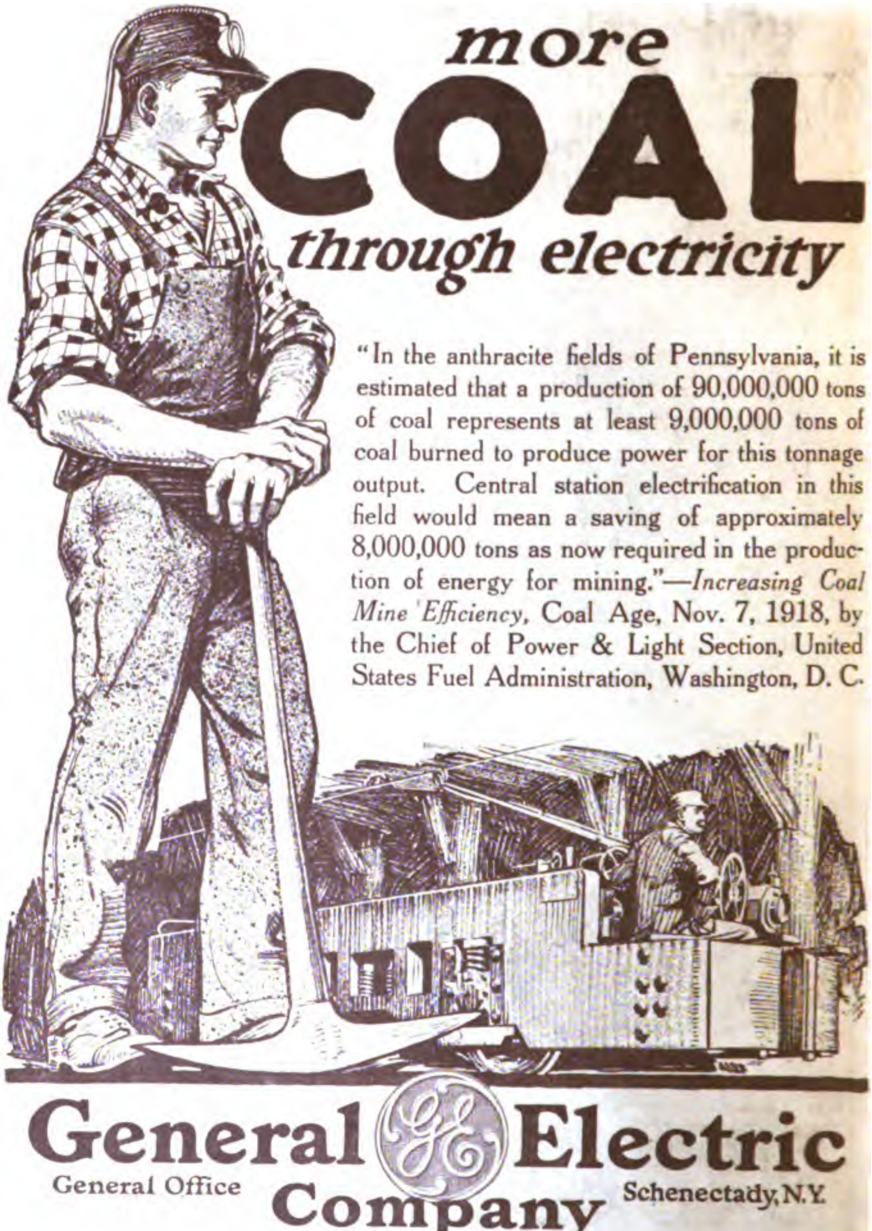
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General Office
Schenectady, N.Y.